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THE CAMP GREENLEAF SCHOOL OF ROENTGENOLOGY

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PHILADELPHIA

THE Camp Greenleaf School of Roentgenology was started on January 2, 1918, with Major Ralph W. Holmes, M. C., assigned as temporary director. On January 10, 1918, Lieut. Colonel Willis F. Manges, M. C., director of the school, arrived and took up the work according to the plan of the Surgeon General's Office.

The function of the school at this time was to select the medical officers best fitted for service as roentgenologists, and to give them a preliminary course of instruction in the following subjects: Principles of Interpretation; Anatomy (particularly of the bones and joints) as revealed by *x*-ray plates; Pathologic Changes; Standard Radiographic Positions (drill); Fluoroscopy; Stereoscopy; Report Writing; and the handling of unexposed plates.

This work was carried on in the *x*-ray department of the base hospital, which consisted of three rooms: a radiographic room, a fluoroscopic room, and a very small developing room. Captain J. C. Howard, M. C., was in charge of the laboratory and offered the school every facility and cooperation. He also served as assistant instructor prior to being assigned to overseas duty. Captains James W. Levering and H. B. McEuen were also assigned as assistant instructors. Capt. McEuen has since gone to duty in France. The space was very inadequate, but the clinical material was extensive, and the enthusiasm of the instructors, as well as of the student officers, was of a high degree. It was apparent that much could be accomplished in larger quarters, and it was further the early conviction of the director that, with adequate accommodation and equipment, there were many advantages here in favor of making this a school for a complete course of training, and even of its being the only school of its kind in the United States.

The director had prior to this conducted a school of military roentgenology in Philadelphia at the Jefferson Hospital where the laboratory was large, well equipped and the clinical material abundant. There were many advantages, but also many disadvantages. The director, for instance, was subject to almost constant interruption by the hospital staff; many of the patients objected to the student officers being present, and the equipment, while of the best, was not that adopted by the army. Then too, neither the instructors nor the student officers had any idea of military regulations, customs or courtesies, and there was therefore an entire lack of military spirit or atmosphere present. There were too many attractions outside of the school work, and the officers had to spend almost all of their pay in living expenses. The director found it difficult and at times embarrassing to keep private patients from interfering with his military duties, and after six months' experience was decidedly in favor of discontinuing the local schools and concentrating the work where the in-

struction could be standardized and the equipment would be of the type sent to the front.

Standardization of equipment was, of course, a most important matter and this was carried out to great advantage in connection with the school in New York; but after this task had been practically accomplished it was considered possible so to equip the school at Camp Greenleaf that it would possess all the advantages of the complete school at New York, none of the disadvantages, and many other advantages in addition to those in New York.

course of instruction, graduating twenty-four medical officers each month, and twenty-four enlisted men per month after a two months' course of instruction. The matters of equipment and of the necessary increase in the teaching staff were left for discussion with Lieut. Colonel Johnston of the *X*-ray Division of the Surgeon General's Office, who came to Camp Greenleaf in May for this purpose. At this time a complete equipment list was made out, and a staff of instructors selected. We were informed that the plan would be carried out and that we would take over the work

FIG. 1. CAMP GREENLEAF SCHOOL OF ROENTGENOLOGY.

These thoughts were brought to the attention of Colonel Page, the Commandant, and Colonel Brooke, Chief Instructor, both of whom encouraged the director to present the proposition to Colonel A. C. Christie, head of the *X*-ray Division of the Surgeon General's Office. We were assured in turn of every support in the matter of development of the school.

Because of the crowded condition of the hospital extra space was difficult to obtain. During the latter part of March steps were taken to secure Post Barracks building "S" for the *x*-ray department of the hospital, but possession of this was contingent upon the completion of new ward buildings. Plans were drawn for the necessary building changes, and a schedule for the complete course of instruction was made out in every detail on the basis of a three months'

of the New York School just as soon as the building could be made ready.

During the first week in June the director was ordered to report to the New York School to investigate the methods of teaching, and to select from the equipment there any apparatus that would be suitable for the school at Camp Greenleaf. The equipment of the elementary physics laboratory, consisting of six instruction units, and the equipment of the localization laboratory, together with other standard pieces of apparatus and some office furniture, etc., were selected.

In the meantime two rooms had been added to the original *x*-ray laboratory, which, with an additional machine, a table, and a bedside *x*-ray outfit, materially added to the teaching facilities. The classes of January, February and March were sent

to New York to complete their training, while the classes of April, May and June were held at Camp Greenleaf awaiting the arrival of the equipment for the new school to complete their technical training.

During April Capt. Frank E. Wheatley was assigned to the school as instructor in machine operation, and during June Major A. W. George, Capt. E. S. Blaine, Capt. Myron B. Palmer, and Capt. Livingston Middleditch, Jr., S. C., also reported as instructors.

The apparatus from the New York School left New York on June 28th, arrived at Camp Greenleaf on July 15th, and the localization laboratory, consisting of six complete units, was installed in temporary quarters so that instruction in localization of foreign bodies was started on July 17th. The elementary and advanced physical laboratories were installed in hospital tents and were ready for operation when electric current was first available on July 24th.

By working three sections a day the student officers of the previous classes had received their final instruction in machine construction, repair and operation, and in localization of foreign bodies, by August 6th, and their work was so arranged that the class entering the school August 1st could take up the regular assignments of the complete course.

Work in the tents and temporary localization laboratory continued throughout the time that the building "S" was being arranged for the *x*-ray laboratory of the hospital and for the permanent quarters of the school. These changes were practically completed by the middle of August.

No sooner had we entered the new school than we were called upon to take larger classes. The space and assignment sheet permitted of doubling the output, and it was decided to shorten the course to two months in order to hasten the supply of roentgenologists. In shortening the course, the more advanced clinical instruction was sacrificed rather than work in localization of foreign bodies, the machine course, and anatomy and position drill.

By the middle of September we were called upon again to double the number of student officers and enlisted men; or, in other words, to furnish one hundred officers and one hundred enlisted men each month. This required both additional space and a rearrangement of the assignments, so that fifty officers and fifty enlisted men could be taken into the school each two weeks. Accordingly the adjoining building, known as "T," was secured and fitted up for the purpose.

The teaching staff had to be enlarged each time the demands were increased and

FIG. 2. REAR VIEW, SCHOOL OF ROENTGENOLOGY.

to this end we were fortunately able to secure the services of Major Wm. H. Stewart to teach the roentgenology of bone and joint pathology, and to look after the details of all clinical instruction. Major A. W. George was transferred to Camp Devens. Major Percy Brown, who had been in active service in France for more than one year, came to the school early in September and delivered a course of lectures with a view of bringing to the instructors and student officers an intimate knowledge of the conditions at the front and to spur all to more enthusiastic effort. These lectures were a source of inspiration to all. Lieut. Charles A. Waters also came to the school as instructor in September after having been in active service in France for more than one year, and having seen all the conditions under which *x*-ray work had to be done in the war zone. In addition to his courses of lectures Lieut. Waters also directed the radiographic and fluoroscopic examinations of the hospital patients, in which capacity he succeeded Captain Myron B. Palmer, who was transferred to the Surgeon General's Office for duty. Notes of Lieut. Waters' lectures are appended. This close contact with one who had been at the front was a factor of the greatest appreciable value to the director as well as to the instructors and students. A number of changes were made in the schedule as a result of conferences with Lieut. Waters.

Instructors at all times were selected solely on their fitness to teach some particular phase of the work, and in the majority of instances were officers who previously had been student officers in the school. In this way the desired results were obtained without at any time keeping at the school large numbers of men who had had wide practical experience. Each instructor was given the opportunity of selecting his own assistants from the classes, and wherever it was possible enlisted men, or non-commissioned officers, or Sanitary Corps officers were used in the strictly technical or mechanical phases of the instruction; for example, in the developing room, physical laboratories, and mobile unit manipulation. The instruction to manipulators was given entirely by Sanitary Corps officers and enlisted personnel.

The curriculum of the school was at all times based on the idea that men were being trained to do the kind of *x*-ray work that was met with at the front, both in the forward hospitals and those farther from the fighting line. In this connection we followed the advice of Lieut. Colonel Case, Senior Consultant in Roentgenology, A. E. F. It was of prime importance that the officer should be able to operate properly any type of machine, and to keep his machine in operation even under the most trying circumstances, that he should know all parts of his apparatus thoroughly so as to be able directly to supervise the installation or dismantling and transportation. The instruction in development of plates was given with more intensity to the manipulators than to the officers.

The course in anatomy and position and exposure drill was looked upon as one of the very important features, since the whole subject of reports, whether of localization of foreign bodies, of fractures, or other lesions, is based upon an accurate use of anatomical terms, and knowledge of the appearance of the normal was considered essential to the easy recognition of the abnormal. It also afforded the opportunity to all the students of making practical application of the instruction they had just received in the machine course. This course was further augmented by fluoroscopy of the normal.

Localization of foreign bodies was taught just as thoroughly as possible with complete equipment and models containing foreign bodies. It was one of the most satisfactory features of the course as well as one of the most important.

Of the clinical subjects, most attention was paid to fractures and diseases of the bones and joints, especially the infections following war injuries. In addition to the

lecture course, in which carefully selected lantern slides were used for illustration, a large collection of original radiographs were studied by sections of the class under the guidance of Major Stewart and his assistants. Special consideration was given to the matter of report writing in this section work.

The instruction with reference to the chest and its contents followed very closely by means of lantern slides as well as by section work in the radiographic and view box rooms. The clinical material was at all times abundant.

The instruction in the diseases of the gastrointestinal tract and urinary tract was given by means of slides and in the radiographic and fluoroscopic rooms. No attempt was made to be thorough except in the matter of technique. This class of

FIG. 3. ENLISTED MEN PERMANENTLY DETAILED TO SCHOOL OF ROENTGENOLOGY.

1. J. D. Durham
2. E. P. Newman
3. O. C. Hamby
4. R. M. Groesbeck
5. Sgt. W. W. Bennett
6. F. W. Sweigert
7. E. Singley
8. Sgt. W. J. Taylor
9. Corp'l G. C. Friend
10. Sgt. W. E. Darling
11. Sgt. L. S. Uphoff
12. Sgt. J. W. Young
13. Sgt. Dunn
14. Sgt. H. J. Boudreau
15. Corp'l H. A. Dart
16. Sgt. C. Hustedt
17. Sgt. C. T. French
18. Corp'l C. E. Sampson
19. Wm. Tolly
20. T. J. Moffett
21. S. Goodman
22. Corp'l E. E. Schowalter
23. R. S. Schiller

the text of the U. S. A. X-Ray Manual, lantern slides being used largely for instruction in interpretation. The hospital furnished a large amount of lung material so that each student studied numbers of patients both fluoroscopically and by means of stereoscopic plates, or single plates taken at the bedside. The time allotted for this instruction permitted close attention only to the more gross lesions, such as fairly well advanced tuberculosis, pneumonic consolidations, effusions, pneumothorax, etc. The diseases of accessory sinuses, mastoids, and teeth were taught patients, however, furnished opportunity for a large amount of fluoroscopy and no occasion was lost to give the student officers opportunity to use the fluoroscopic apparatus. There were a considerable number of requests for gastrointestinal examinations, but very few organic lesions were found to be present.

All departments of the hospital were encouraged to request bedside examinations of patients too ill to be moved. This work was done mainly by the students under the supervision of a capable instructor. The results were of surprising excellence and

the number of patients examined per day was usually quite large. On one occasion Lieut. L. L. Rogers, chief instructor in bedside work, made nineteen very satisfactory radiographs of the chests of the same number of patients in twenty-nine minutes' time, and some of the patients were quite ill. This bedside work was thoroughly appreciated by all of the various chiefs of service, and was of the utmost value to the school as a means of instruction.

technique of extremities, and standard positions of other parts.

In addition to the instruction given to the students of the School of Roentgenology, courses of illustrated lectures or fluoroscopic demonstrations were given to the student officers of the various other schools at Camp Greenleaf. For example, two lectures a week were given to the School of Surgery, two to the School of Orthopedic Surgery, one to students in

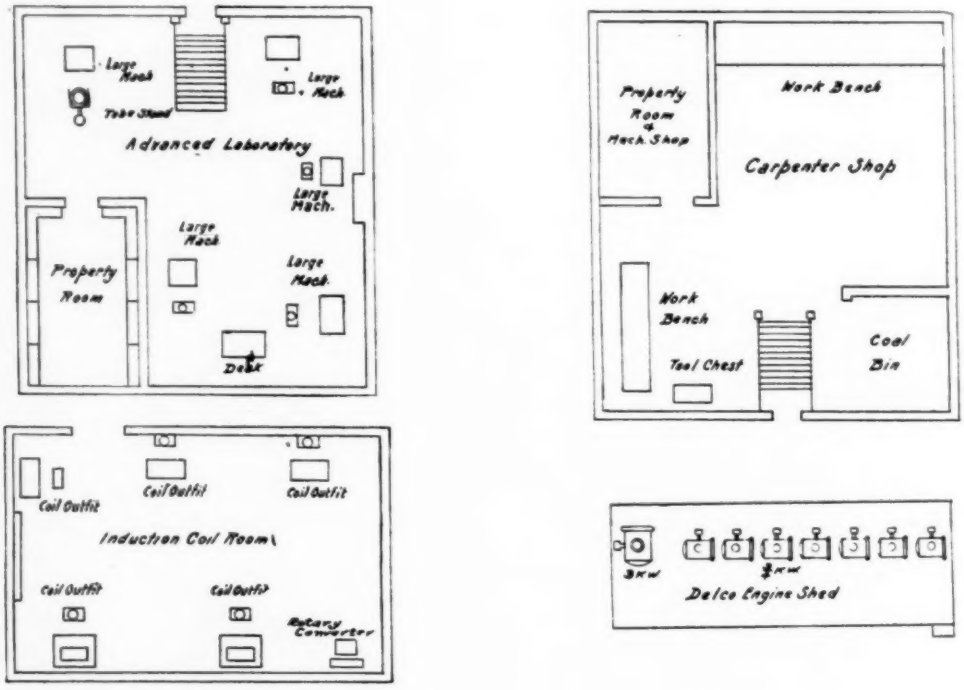


FIG. 4. BASEMENT ROOMS AND ENGINE SHED.

Instruction in the therapeutic use of *x*-rays was limited to individual training in operation of the Coolidge tube at a standard treatment exposure set of conditions, and in the use of filters, protection of surrounding parts, etc. No attempt was made to teach the application to any particular disease.

Instruction to enlisted men was limited to operation, care and repair of apparatus, developing room work, assisting in the radiographic and fluoroscopic rooms, the filing of records and plates, and exposure

Otolaryngology, one in Oral and Plastic Surgery, and occasional demonstrations to the School of Cardiovascular and Lung Diseases. The object of these lectures and demonstrations was to acquaint the several specialists with the sort of aid they might expect to get from the *x*-ray department, and to cultivate as much as possible a healthy spirit of cooperation. This matter of cooperation was further carried out by having at all times available a capable instructor who could take plates and records to the surgical operating rooms or

wards on occasions when such records might be of value in operations or in the instruction of the various classes. The instruction thus given to the various other specialties was started early in January, 1918, and was carried on throughout the year, we believe with a great deal of benefit to all concerned. In fact, this very feature was looked upon as one of the important reasons for having a very complete school of roentgenology at Camp Greenleaf.

The floor plan of building "S" was arranged with special attention to the hand-

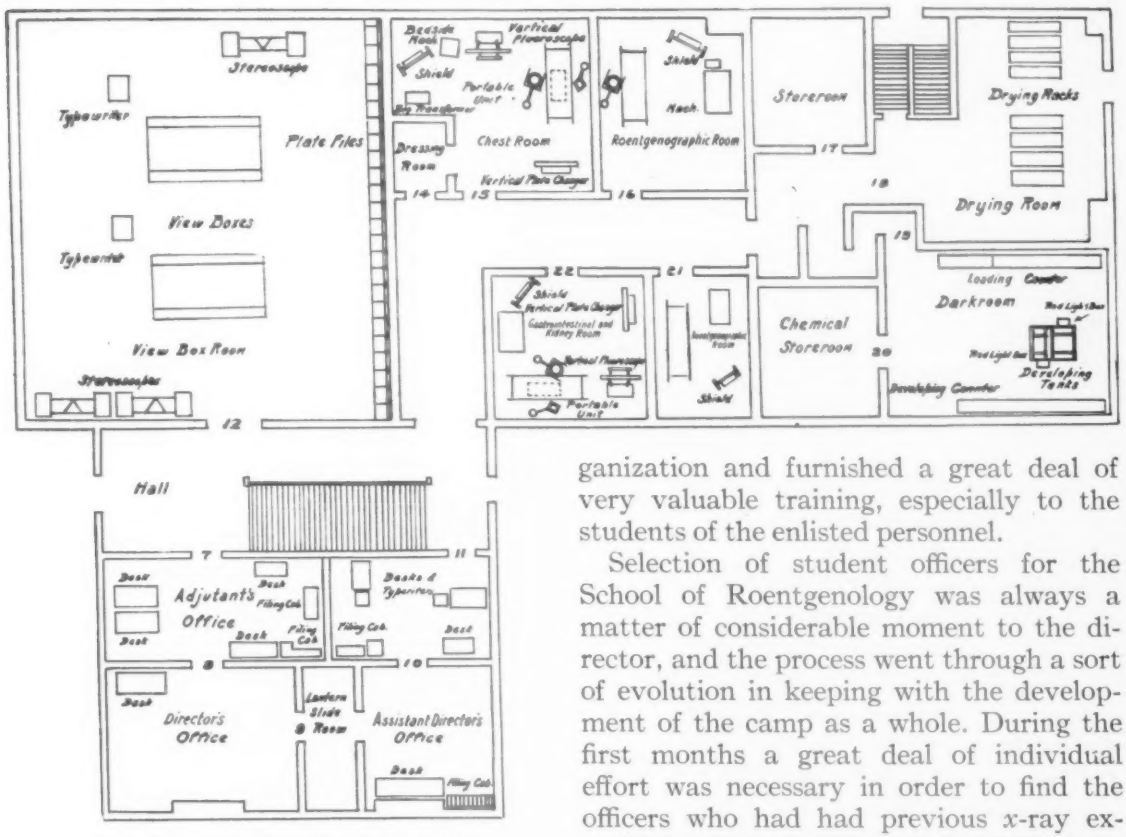


FIG. 5. FIRST FLOOR OF WARD "S."

ling of a large number of patients; or, in other words, primarily as an *x*-ray department of the hospital, and secondarily with a view to school purposes. Fortunately the plan worked well for both, the first floor and part of the second floor especially for the accommodation of patients, and the remaining part of the second floor, as well as two basement sections were more for school purposes. All changes were planned in such a manner that by the mere tearing down of the partitions and removal of apparatus the building would be in its original condition without damage. The partitions, ventilating, light-proof shutters, and most of the wiring in this building were done by outside contractors, but all the installations and a considerable amount of wiring were done by the officers and enlisted personnel of the school. All the work in building "T" was done by the school organization and furnished a great deal of very valuable training, especially to the students of the enlisted personnel.

Selection of student officers for the School of Roentgenology was always a matter of considerable moment to the director, and the process went through a sort of evolution in keeping with the development of the camp as a whole. During the first months a great deal of individual effort was necessary in order to find the officers who had had previous *x*-ray experience, and it was at times difficult to get and especially to hold them. The plan of calling for volunteers by means of notices read to the companies brought forth a large number of applicants, among them many who were not well fitted for the work, but the plan did have the advantage of bringing the opportunity to the attention of those who had had previous experience. The greatest objection to this plan was the

fact that it frequently turned out that the men selected had been retained at the Surgeon General's Office for some other service, and we learned of it only when orders came taking such men from the school. Later, the board of examiners, who examined all officers entering the camp in surgery and medicine, referred to the *x*-ray school all officers who claimed to have had any experience whatever in *x*-ray work, or who especially desired to take up the work.

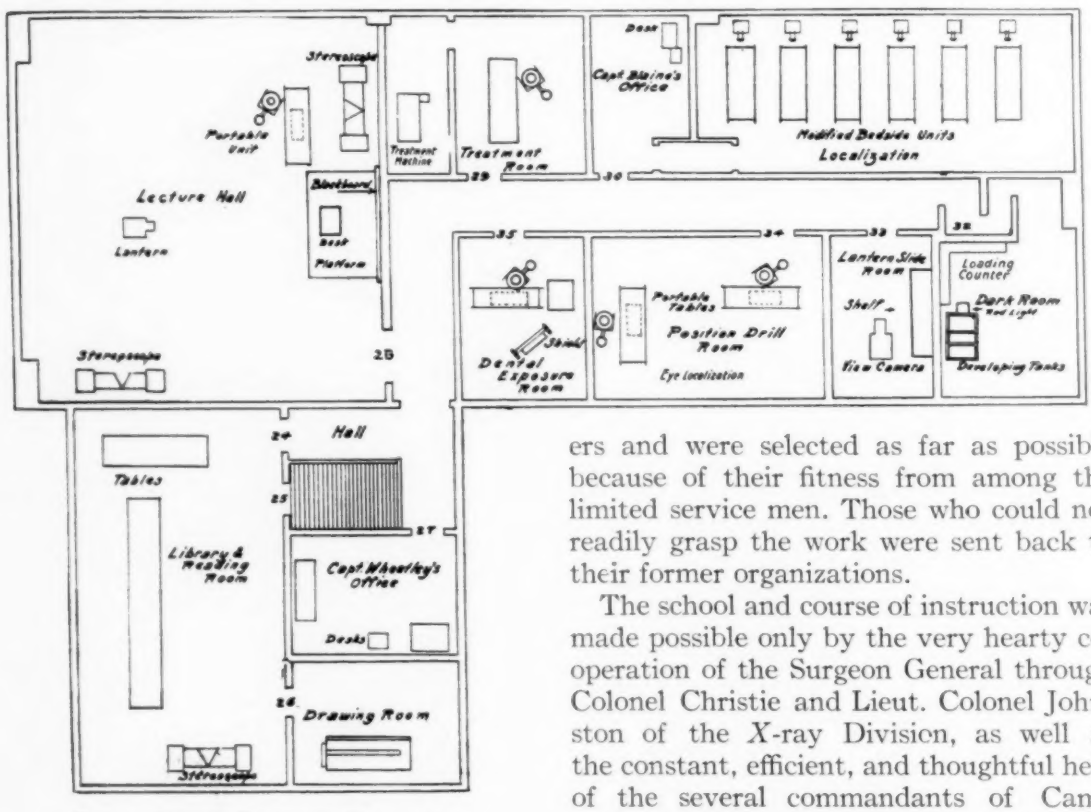


FIG. 6. SECOND FLOOR OF WARD "S."

By this means a little more than half the desired number of students were obtained. In order to fill up the classes the president of the board of examiners selected from the files the cards of men who had passed good examinations in surgery, but who had not been taken up by the Surgical Chief. It was considered a matter of importance that the student roentgenologists should know surgery, for they were to be surgical assistants of the first degree of importance. With this class of officers, mostly under forty years of age, some of the most gratifying results were obtained. They were particularly adaptable to training for forward hospitals where the work was largely a matter of localization of foreign bodies and study of fractures. This plan was found to be the best obtainable and was fairly satisfactory.

The enlisted personnel were obtained entirely through various group commanders and were selected as far as possible because of their fitness from among the limited service men. Those who could not readily grasp the work were sent back to their former organizations.

The school and course of instruction was made possible only by the very hearty cooperation of the Surgeon General through Colonel Christie and Lieut. Colonel Johnston of the *X*-ray Division, as well as the constant, efficient, and thoughtful help of the several commandants of Camp Greenleaf and their respective staffs. The actual work in the school was carried on with the greatest ease and satisfaction because of the most enthusiastic spirit of loyalty, pride and cooperation that existed in the school organization. The director had the entire confidence of the *X*-ray Division, and in the matter of equipment, supplies, and assistants, was cared for with the utmost promptness. As stated before, the plan of the school was conceived during the time Colonel Page was commandant, and his encouragement, advice, and as-

sistance were responsible for much of the thoroughness of the idea. During the term of office of General Birmingham local conditions prevented rapid progress, but every encouragement and assistance were again forthcoming. It was, however, during the term of office of General Munson that the actual expansion was accomplished, and constructive work was done. The development at this stage was very rapid and was possible only because of the close personal interest and help of General Munson. During the final months, Colonel Bispham, who succeeded General Munson, gave the school every consideration and assistance. Colonel Roger Brooke, the officer in charge of all instruction work at the camp, was also greatly interested in the school and especially in the actual teaching plan. A physician, surgeon, and roentgenologist of real ability, as well as a regular army officer of the highest type, his interest in the school was of the utmost value throughout the entire year of our work. Thus we enjoyed the confidence and assistance of the entire camp organization throughout the year of the school's existence. In fact, the success of the school was due quite as much to the constant support of the commandants and their entire organizations as to the efforts of the school organization.

We believe that special mention should be made of the value of the military training given the students of the school, both before and during their course of instruction in *x*-ray work. Early in the year many of our students had been in the military training course for a matter of one or more months. Quite a number of them had been captains in their company organizations or had held some other office in the strictly military organizations. These men stand out in our minds as the best students, the men whom we could recommend for responsibilities. To our personal knowledge these men have all made good records in

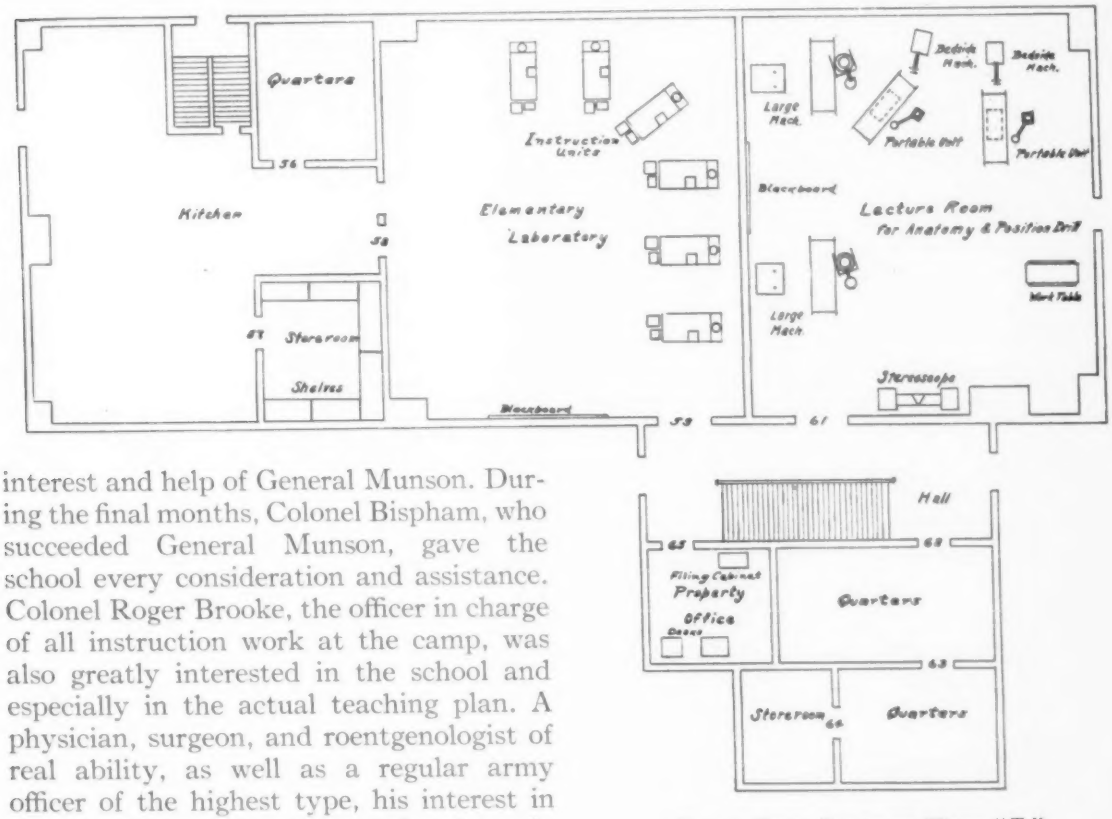


FIG. 7. FIRST FLOOR OF WARD "T."

active service, some of them under the most trying circumstances. Toward the latter part of the year less and less time was given to military training and the lack of interest in the school kept pace. During the last few weeks we were compelled to take in officers who had had practically no military training and it was difficult at times to maintain discipline in the different departments of the school, although we had much less difficulty with the *x*-ray classes

in this respect than we had with classes from the other schools. It is a conviction that a school of this size, under conditions requiring such an intensity of application, could not possibly be a success without the students having first been thoroughly instructed in the ideas and ideals of military discipline, and we feel this could not be accomplished in less than one month.

The Camp Greenleaf School of Roentgenology has accomplished a large amount of educational work. Primarily, this was done with the idea of helping to win the war. But it is worthy of note that the school has done much toward the elevation of the standard of *x*-ray work of the country, and this will be a lasting benefit in after-war days. We believe there never has been another school of roentgenology that has even approached this one in the way of equipment, facilities for teaching, teaching staff, or curriculum, and the probabilities are that it never will be surpassed. It was made possible by the rapid development of *x*-ray apparatus for the army. In fact, this development has been so rapid that we seem to have entered a distinct epoch in this branch of science, and it seems reasonable to believe that we will not see many radical changes in the matter of apparatus for some years. In short, the *x*-ray equipment of the United States Army is entirely satisfactory.

We feel it a duty to recommend that the school should be perpetuated in every detail except as to dimensions and duplications, and that all medical officers on entering the service in the regular army should have this course of instruction.

The whole scheme has worked well and we feel that the schedule as to the number of hours devoted to each phase of the subject represents the minimum that is practicable for obtaining efficient result. It is a strong conviction, however, that such a course should be given to men who are still young enough to be students, and within a short time after graduating in medicine, or preferably during their medical course.

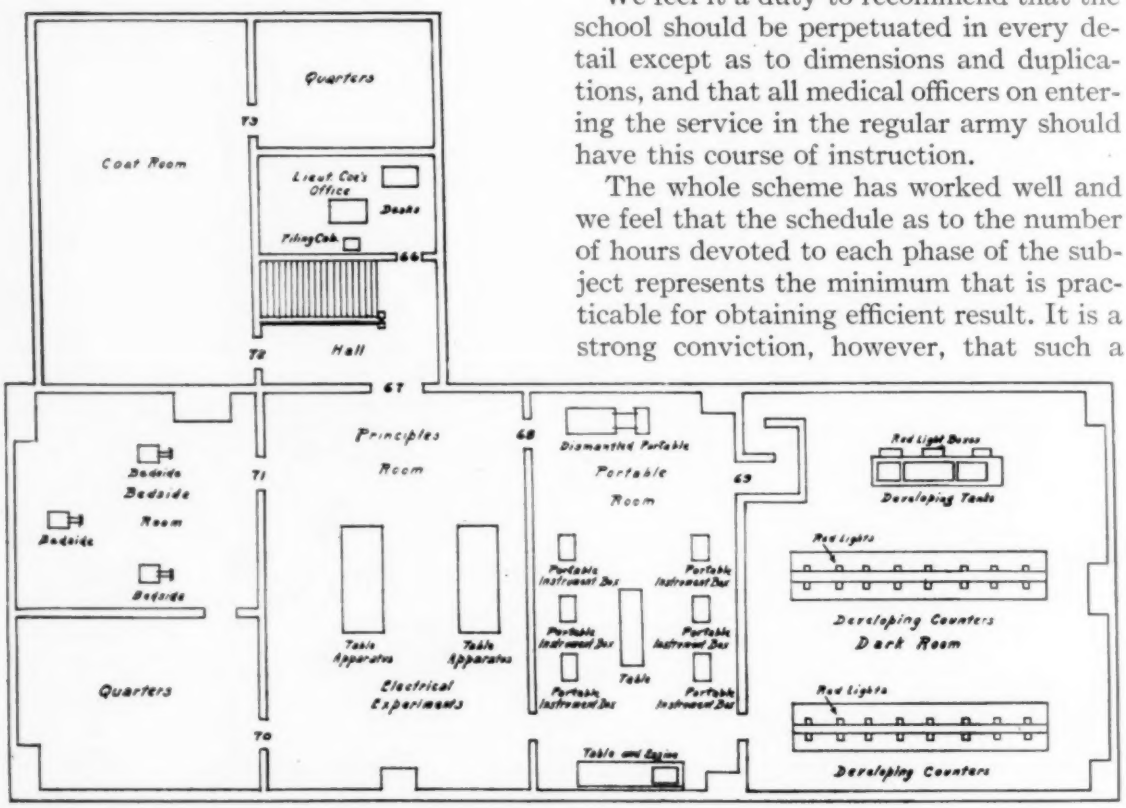


FIG. 8. SECOND FLOOR OF WARD "T."

The history of the development of the Army apparatus will be recorded elsewhere. It has been a most important part of the scheme of preparedness, for the most part due to the genius of Dr. Coolidge. The plan of instruction in the physical and elec-

trical aspects of the course is to be credited almost entirely to Lieut. Colonel J. S. Shearer, S. C., U. S. Army, and the chapter on physics in the U. S. Army X-Ray Manual is the best evidence of the truth of this statement. All instruction in localization of foreign bodies, in the purely clinical subjects, and in the practical application of the whole has been, as before stated, based on the needs of the occasion, largely as expressed by Lieut. Colonel James T. Case, M. C., U. S. Army, Senior Consultant in Roentgenology, A. E. F. The development of the scheme of instruction up to its final stage has been due to the loyal and efficient cooperation of all those who have from time to time been a part of the teaching staff at the Camp Greenleaf School.

The entire result is, we believe, not the least evidence of the broadminded, generous and efficient policy of the Surgeon General of our Army.

OUTLINE OF COURSE IN *X*-RAY PHYSICS AND ELECTRICITY, ELEMENTARY AND ADVANCED LABORATORIES.

Instructor: Major Frank E. Wheatley, M. C.; *Assistant Instructors:* Lieut. F. H. Roepke, M. C., Lieut. J. B. Bond, M. C., 2d Lieut. L. S. Uphoff, S. C., 2d Lieut. W. W. Mowry, S. C.

Purpose of the Course.—This course is designed to acquaint medical officers selected for *x*-ray service with the various types of apparatus they may be called upon to operate when assigned to duty. While there is no intention to attempt to make electricians or physicists of them, still a considerable amount of time is spent upon the principles underlying the production of *x*-rays. This is deemed necessary in order that the men may have a basic knowledge that will enable them to render continuous efficient service, under the varying and often adverse condition of Military Roentgenology.

It is not necessary to enumerate the difficulties which may confront a man when on field service, away from technical or material aid. Throughout the course, attention is directed to measures designed to *keep the work going* under the most adverse conditions.

Outline of Instruction.—The quickest and most thorough way of learning is by doing. For this reason, laboratory work comprises the major part of this course. A source of danger, however, in laboratory work with a large number of men, is the probability that the men who have already had some training will do all the work, letting the men who most need the experience look on. To overcome this, the sections and apparatus are so arranged that each man must himself do the work under the supervision of an instructor. The only objection to this plan is that it demands more than the usual number of instructors and hence added expense. This objection is largely overcome by using selected enlisted men to act as assistants on the various units, all work being done under the direct supervision of a medical officer.

The laboratory work is given in several parts. First the men gain a fundamental knowledge of electricity by doing selected experiments on a unit called the "Principles of Electricity Table." Hereafter this unit is designated by the term "Principles Table." The class is given instruction in the operation of the rectifying type of machine on units called "Test Machines." Succeeding this, the following units are taken up: U. S. Army Portable Gas Electric Set, U. S. Army Portable Instrument Box, U. S. Army Bedside Unit, Induction Coil Outfit (gas tubes) and, finally, the various makes of Base Hospital Machines.

Each morning before the class goes into the laboratory, the lecture is given. The course of lectures is designed to parallel the laboratory work as closely as possible, and follows literally the text of the Manual with simple analogies for explanation. The last five lecture periods are devoted to review, and opportunity is given the class to clear up any points not made clear on first presentation.

Camp Greenleaf School of Roentgenology, Chickamauga Park, Ga.

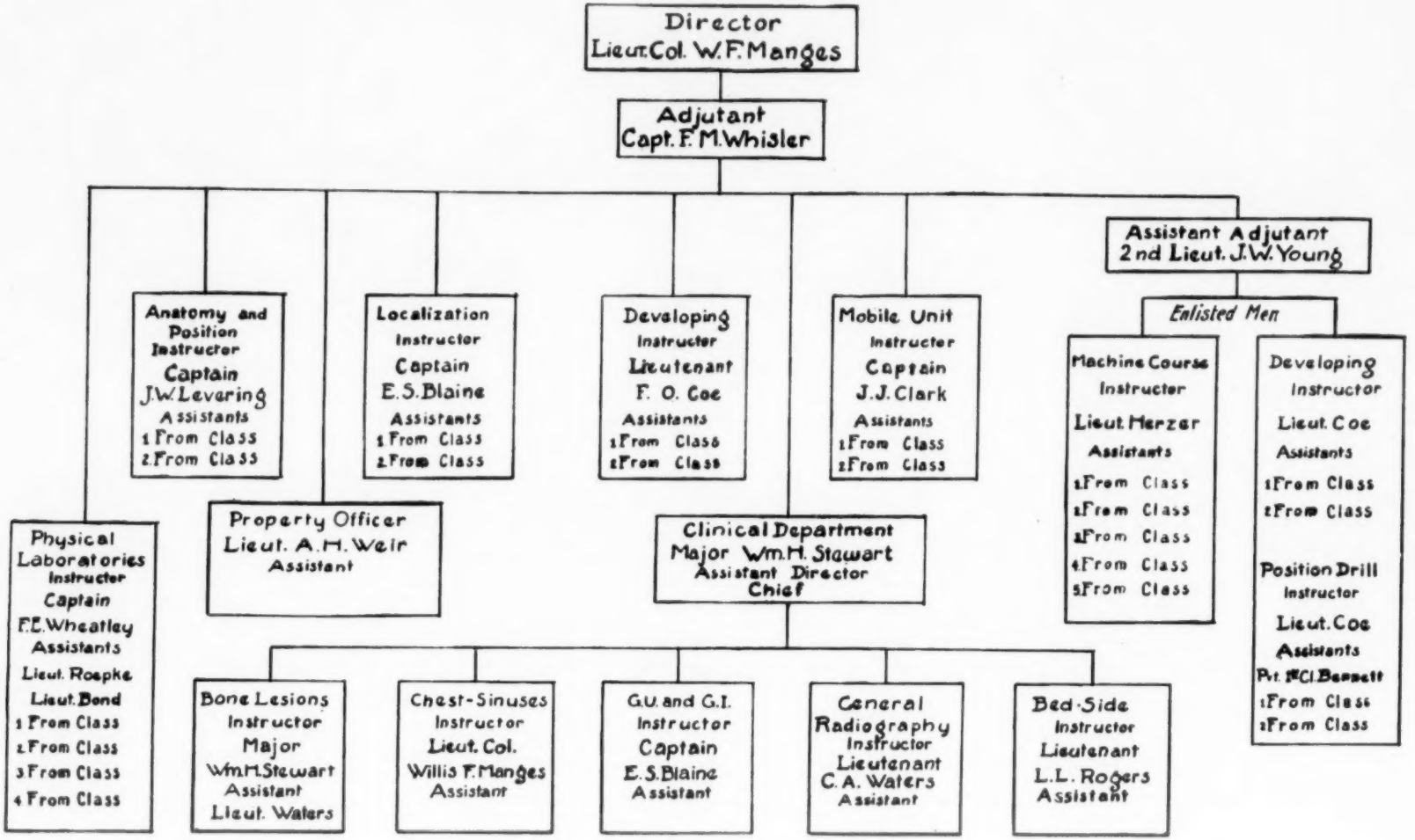


FIG. 9. ORGANIZATION CHART.

Following is a résumé of the work done under each of the above headings.

The last day of the course is devoted to an interview between each man and an instructor. In this way, each man is "sized up" in respect to his practical application of knowledge gained in the course.

Principles Table.—This table has been designed to give men a conception of the physics of *x*-ray work.

Experiment 1 is an exposition of Ohm's Law. By means of resistance units and meters, the men are shown the relation between voltage, resistance and current.

Experiment 2 shows the presence of magnetic lines of force about a conductor carrying direct current, a compass being used for their detection.

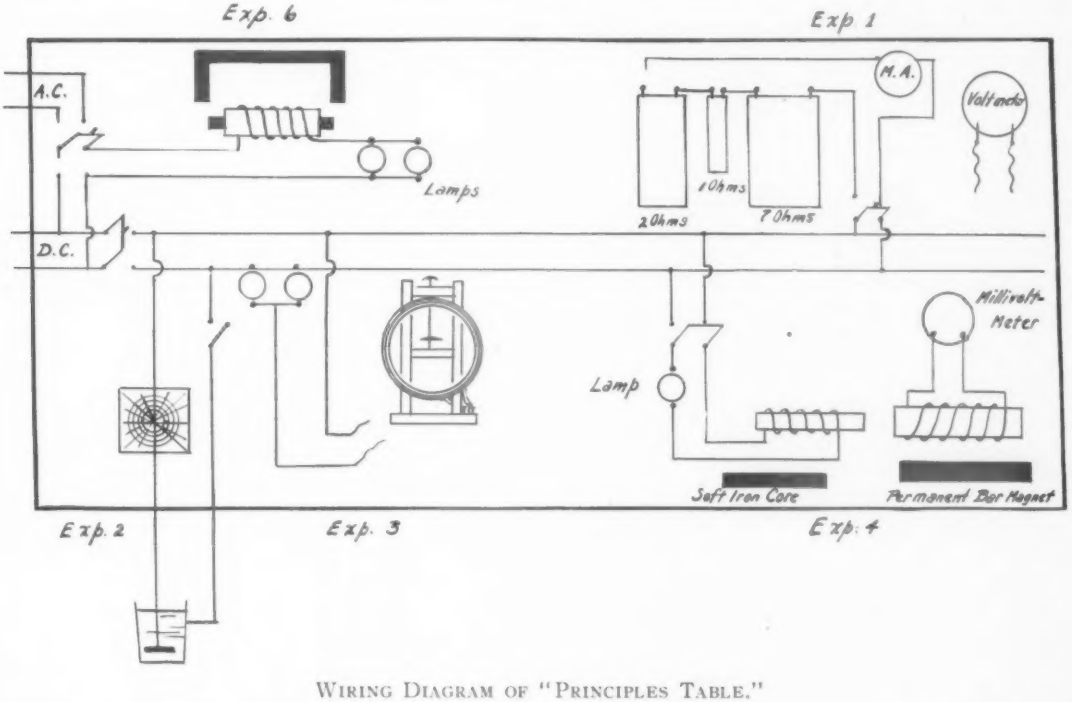
Experiment 3 shows the relation between the current in a conductor and the direction and intensity of the resulting magnetic lines of force.

Experiment 4 demonstrates the theory of induction, showing the multiplicity of methods which may be used for the production of induced voltage. Emphasis is laid on the fact that all the methods are simply ways to "cut" magnetic lines of force by a conductor.

Experiment 5 illustrates the closed core transformer. A model transformer is used to show the relation between primary and secondary in respect to voltage, amperage, and the number of turns of wire. The difference between autotransformer control and rheostat control is also explained.

Experiment 6 demonstrates self-induction. Attention is directed to its presence in every transformer and in choke coils, and the student is prepared for the explanation of the autotransformer.

Experiment 7. A model autotransformer is used to illustrate the fixed primary, variable secondary principle of autotransformers.



WIRING DIAGRAM OF "PRINCIPLES TABLE."

Experiment 8. An autotransformer with taps, illustrates the commercial form of this appliance.

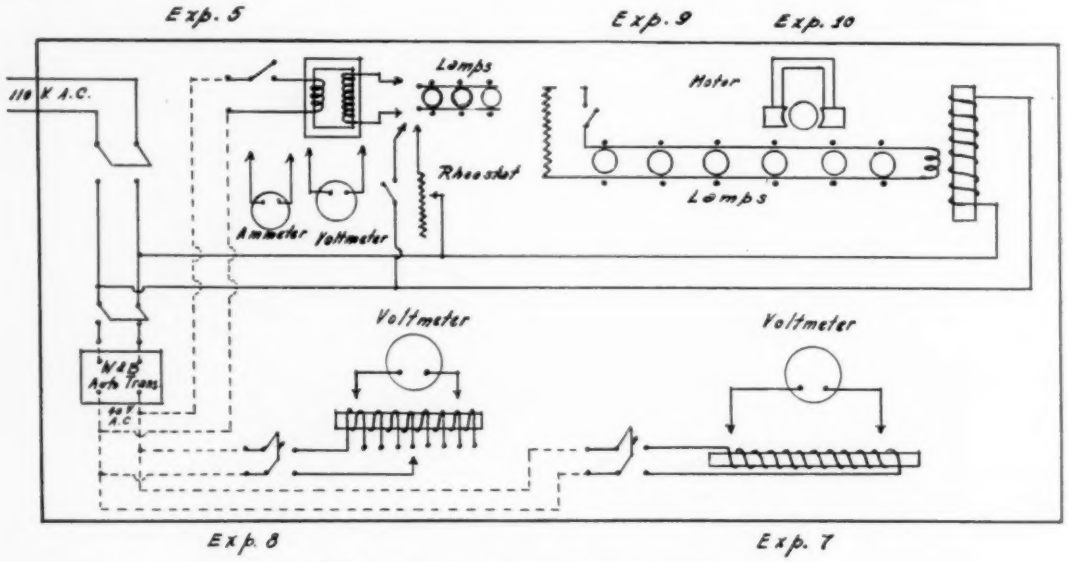
Experiment 9. Voltage drop along the line is illustrated by the use of lamps arranged along an inadequate conductor in which the load is varied.

Experiment 10. A toy magneto-motor arranged for A.C. and D.C. shows the

principles underlying the rotary converter.

Throughout the work on this table, the fact that we are training *x*-ray men is kept constantly in mind. Every opportunity to show the relation between the experiment and *x*-ray machines is made use of. In practice, this part of the course seems to have filled a long-felt want, as men who have had it approach an *x*-ray machine with a much clearer conception of its action.

Test Machines.—These are special units designed by Lieut. Colonel J. S. Shearer, S. C., and Capt. L. Middleditch, S. C., for use in the New York School of Military Roentgenology, and show clearly the basic principle of all *x*-ray outfits. They also are used to demonstrate the action of *x*-rays on a photographic plate under the actual conditions of operation.



Wiring Diagram of "Principles Table"

The first day in this laboratory is devoted to the study of the wiring and component parts of the unit. Diagrams are required to check up on the man's ability in this line.

The second day is devoted to rewiring the outfit, the wiring having been removed before class. After each unit has been inspected to avoid accident, they are operated with the improvised wiring.

The third day the machines are "charted" and attention is again directed to the difference between rheostat and autotransformer control. Then an experiment is performed which demonstrates the saturation point of a Coolidge tube.

The fourth day is devoted to experiments with test plates, showing the relation between photographic effect and distance between the tube and the plate—the inverse square law. Then the relation between photographic effect and the current is demonstrated.

The fifth day the relation between voltages as measured by spark gap and photographic effect is shown. Then a test plate is made in which the photographic effect is kept constant, but the factors of time, distance, voltage and current are varied. Computation from this experiment is made by the men previous to coming into class.

The sixth day is devoted to an experiment showing the desirability of selecting the proper spark gap for radiography. Several exposures are made of a plaster-of-paris block containing a thick and a thin piece of brass. The resulting plate demonstrates penetration and absorption. After this a pin-hole picture of the focal spot of the tube is made.

The last day is occupied by operating the Coolidge tube with alternating current, preparing the men for the operation of the radiator type of tube used on the Portable

and Bedside Units. A test plate to illustrate "scattering" completes the work in this laboratory.

OUTLINE OF LECTURE COURSE

Text of Lectures follow the text of the *X*-Ray Manual.

1. Aims of the course. System of instruction. Electricity—Electron theory, charges, generators, conductors, resistance, meters, circuits, A.C., D.C., units.

2. Electricity—Ohm's law, magnetic lines of force, theory of induction, transformers (laws).

3. Electricity—Self-induction, autotransformers, requirements for *x*-ray tubes, high voltage, spark gap, *x*-ray transformer, *x*-ray machines.

4. *X*-ray machines, autotransformer, rheostat, filament transformer and regulator, milliammeter, spark gap, timer, surge resistances, synchronous motor and rectifier. Diagram.

5. *X*-ray Machines—Review. Wave motions, spectrum, *x*-rays—nature, behavior, uses.

6. Instructions and Precautions. Charts—purpose, autotransformer and rheostat charts. *X*-ray production—Coolidge tube, self-rectifying action of Coolidge tube, electron, voltage, target, focus (broad—fine), saturation.

7. *X*-ray Production—Relation of *x*-ray voltage and milliamperage, practical application of these relations. Relation of photographic effect to voltage, milliamperage, time and distance, laws.

8. Penetration, absorption, scattering. Gas engine of Portable Outfit.

9. Portable Box.

10. Portable Box and Bedside Unit. Exposure tables.

11. Base Hospital Machines—Type followed by all makes. Diagrams.

12. Base Hospital Machines—Wappler, Kelley-Koett, Campbell, Waite & Bartlett, Victor.

13. Base Hospital Machines—Review, rotary converter, D.C. machines.

14. Computation of line wiring. High tension wiring. Dangers—*X*-ray, electricity.

15. Gas tubes. Induction coil outfits. Interrupter. Valve tubes. Oscilloscopes.

ASSIGNMENTS AND APPARATUS

Principles of Electricity Table—(1 unit).
(3 days). Layout of experimental apparatus to illustrate electrical phenomena essential to *x*-ray.

Test Machines—(6 units).
(7 days). Assembled rectifying apparatus to teach principles of machines and Coolidge tubes.

Gas Engines—(4 units—1 dismantled).
(2 days). Units to teach operation and troubles of gas engines.

Portable Box—(4 units—1 dismantled, 3 engines for power).
(1 day.) Wiring and operation.

Bedside Unit—(3 units).
(1 day). Wiring and operation.

Coil and gas tube outfits—(4 units).
(1 day). Operation.

Advanced Laboratory—(6 units). (4 days). Wiring and operation of the various makes of Base Hospital Machines.

TABLE OF WORK ON THE VARIOUS UNITS

Principles of Electricity Table.
Three days' observation and performance of simple experiments to illustrate the essential electrical phenomena.

Test Machines.
Seven days: Tracing, rewire, operate, to show control and action of Coolidge tube and to illustrate technique of radiography.

Gas Engine.
Two days: Studying and operating. Attention is directed to dismantled engine, repair of common trouble, and detection.

Portable Box.
One day: Wiring and operation.

Bedside Unit.
One day: Wiring and operation.

Coils.
One day: Operation of coil and gas tubes.

Base Hospital Machines.
Four days: Operation, peculiarities of the various makes.

Interview. Last day of course.

Assignment Sheet. (Three Months Course) Camp Greenleaf School of Roentgenology

	Elementary Lab AM	Elementary Lab PM	Developing Room AM	Developing Room PM	Position Drill AM	Position Drill PM	Advanced Lab. AM	Advanced Lab. PM	Anatomy and Interpretation AM	Anatomy and Interpretation PM	General Radiography AM	General Radiography PM	Chest AM	Chest PM	Gastro-Intestinal and Genito-Urinary AM	Gastro-Intestinal and Genito-Urinary PM	Dental AM	Dental PM	View Box Rooms AM	View Box Rooms PM	Sinus, Mastoid and Treatment AM	Sinus, Mastoid and Treatment PM	Bedside Unit AM	Bedside Unit PM	Bone Lesions AM	Bone Lesions PM	Localization AM	Localization PM	Photography and Filing AM	Photography and Filing PM
1st Week	AB	CD	CD	AB																										
2nd "	CD	AB			AB	CD																								
3rd "	wx	yz	yz	wx			AB	CD	CD	AB																				
4th "	yz	wx	x	y	w	z	CD	AB	AB	CD																				
5th "					y	x	wx	yz			A x2+5	w	B x1		C x4+6		D x2		ABCD											
6th "			w	z			yz	wx			B x3+5	y	C x1		D x4+6		A x2		ABCD											
7th "					wx	yz					C y-1-3	x	D y4-6	w	A x1-3		B x4-6		ABCD											
8th "											D w1-3	z	A w4-6	y	B x1-3		C x4-6		ABCD										yz	wx
9th "																					A		B	CD		AB	CD			
10th "																					B		A	CD		AB	CD			
11th "																					C		D	AB		CD	AB			
12th "																					D		C	AB		CD	AB			

ASSIGNMENT SHEET, 50 MEDICAL OFFICERS. (TWO MONTHS' COURSE.)

Week		Elementary Lab.	Developing room	Anatomy & Position Drill	Advanced Lab.	Localization	Bone Lesions	Bedside & Portable	General Roentgenography	Chest Gastro-intest.	Mastoid Sinuses Teeth
1st	am	AB	CD								
	pm	CD	CD								
2nd	am	CD	AB								
	pm	AB	CD								
3rd.	am			AB							
	pm			CD	CD						
4th.	am			BD	AB						
	pm			AB	CD						
5th	am					CD	AB	CD			
	pm					AB	AB				
6th.	am					AB	CD	AB			
	pm					CD	CD				
7th.	am								AB	CD	AB
	pm								CD	CD	CD
8th	am								CD	AB	
	pm								AB	CD	

CLINICAL LECTURES

These lectures were given to the medical officers during their second month of the course. They were repeated monthly.

Date	9–10 A.M.	3:30–4:30 P.M.
1	Fractures	Reports and Records
2	"	Stereoscopy
3	"	Fluoroscopy
4	"	"
7	"	Heart and Lungs
8	"	" " "
9-16	Bone Pathology	" " "
17	Joint Pathology	" " "
18	" "	" " "
21	" "	Urinary Tract
22	Head and Dental	" "
23	" " "	" "
24-31	" " "	Gastrointestinal Tract

C and D, of six men each. The enlisted men are similarly divided, the sections being denoted by small letters, w, x, y and z.

Discrepancies between weeks and calendar months are taken care of by reviews and further study on the more important points. Thus the calendar month is always divided into four assignment periods. The school week consists of five working days, Saturday mornings being devoted to examinations on the past week's work.

The school day is made up as follows:

(a) For medical officers during their first month of instruction:

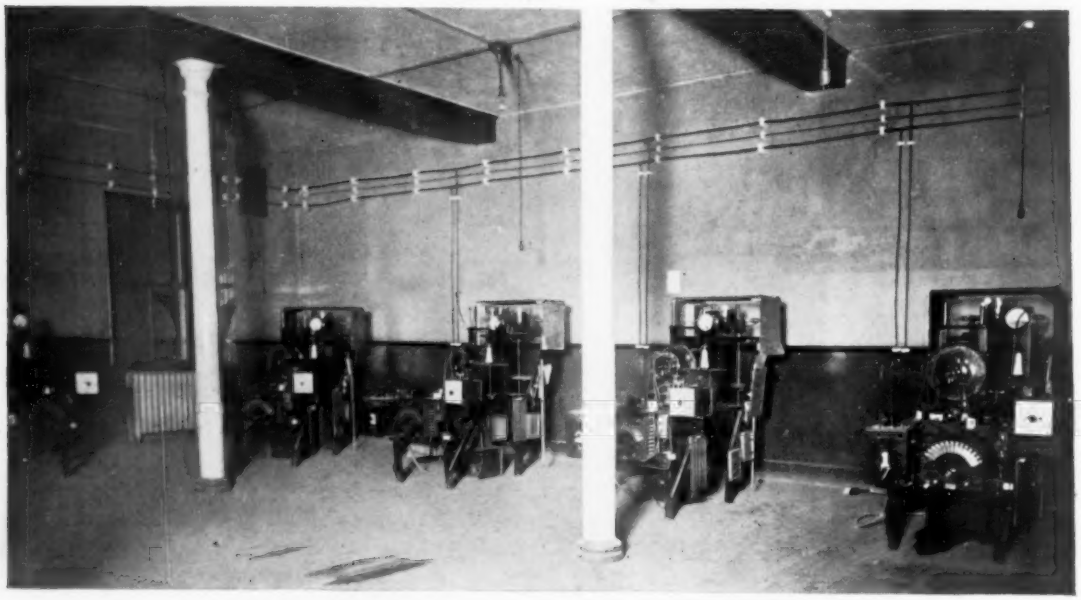


FIG. 10. TEST MACHINES, ELEMENTARY LABORATORY.

THE THREE MONTHS' COURSE

This assignment sheet is based on twenty-four medical officers reporting at the first of each month for a three-months' course and twenty-four enlisted men reporting at the middle of each month for a six-weeks' course. For the sake of clearness the assignments are filled out in skeleton form for only one class of each group. Succeeding classes would have exactly the same assignments, except four weeks later. The twenty-four medical men are divided into four sections: A, B,

8:30–10:30 Section work as assigned.
10:30–11:30 Lecture.
11:30– 1:00 Mess.
1:00– 2:00 Lecture.
2:00– 4:30 Section work.

(b) For medical officers during their second and third months of instruction:

8:30– 9:30 Lecture.
9:30–11:30 Section work as assigned.
11:30– 1:00 Mess.
1:00– 2:00 Lecture.
2:00– 4:00 Section work.

(c) For enlisted men throughout their course:

8:30– 9:00 Care of the apparatus.
9:00–11:30 Section work as assigned.
11:30– 1:00 Mess.

(a) Medical men during their first month. (This series of lectures repeated monthly):

FIG. 11. FIRST VIEW, ADVANCED LABORATORY.

FIG. 12. SECOND VIEW, ADVANCED LABORATORY.

1:00– 2:00 Lecture.
2:00– 4:30 Section work.

The lectures are divided among the various subjects as follows:

Physics and Electricity	15
Review quiz	5
Developing	5
X-ray Anatomy	10

Positions	5
	40

(b) Medical men during their second and third months. (This series of lectures repeated every two months):

Principles of Interpretation	1
Stereoscopy	1
Fluoroscopy	2
Fractures and bone lesions	15
Heart and lungs	10
Pathology (by a Pathologist)	10
Localization	5
Gastrointestinal	8
Urinary tract	2
Head and dental	10
Orthopedic	5
Therapeutics	2
Reports and records	2
Duties of the roentgenologists	1
Miscellaneous	6
	80

(c) Enlisted men. (This series of lectures repeated monthly):

Physics and Electricity	15
Review quiz	5
Dark room work	5
Handling of patients	2
Records and filing	2
Duties of the manipulator	1
	30

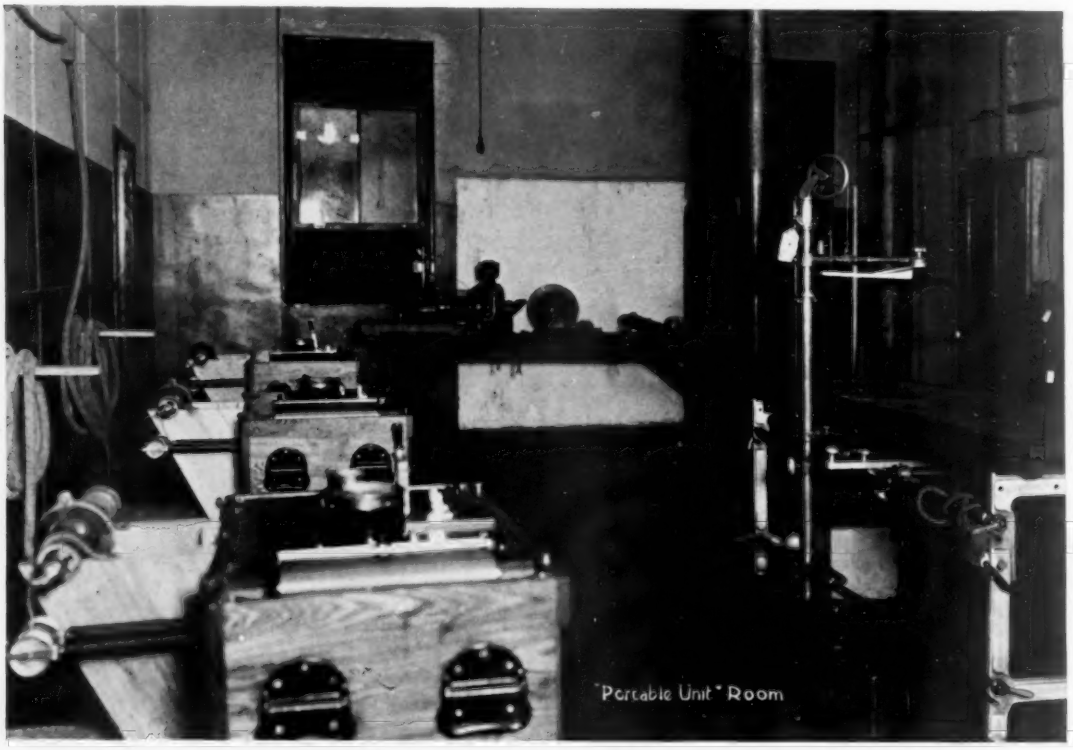


FIG. 13. "PORTABLE UNIT" ROOM. NOTE DISASSEMBLED ENGINE ON TABLE AT END OF ROOM.

The following notes are explanatory of the headings of the assignment sheet:

Elementary Laboratory: This laboratory is intended to give a fundamental knowledge of the *x*-rays and the means of their production. The apparatus is so arranged that all of the working parts and wiring are exposed to view, and the student learns the fundamental principles of any standard *x*-ray machine. He gets a great deal of practical experience in operating the machine and in making experimental plates before he is permitted to make a single exposure of the living subject. The equipment of

this laboratory is very complete and permits of intensive, individual instruction.

Advanced Laboratory: This laboratory is designed to supplement the elementary course by making the student familiar with each of the several standard Army machines. He learns the special features of each type of apparatus and the proper operation of each. Emphasis is laid on the matter of finding and *overcoming* the usual troubles which may occur in the use of these machines under military hospital conditions.

Developing Room: The developing room is so designed that each student receives individual instruction and practical experience in the handling and mixing of developing materials and in the handling and developing of plates and films. This work will be done under the supervision of an instructor experienced in developing room work.

Position Drill: In this room the students are drilled in the adjustments of the tube and the plate to the anatomical part in the standard positions for exposure. The students in turn assume the part of the patient, but they are not exposed to *x*-rays. Emphasis is laid upon the proper handling of wounded patients and the means of supporting injured parts.

Anatomy and Interpretation of the Normal: During this assignment the students are given a course of instruction and review on the bones, joints, and regional anatomy as revealed by the *x*-ray plate. Selected plates of normal parts are used as a basis of interpretation of the normal anatomical

FIG 14. PORTABLE UNIT ROOM. CONTENTS OF PORTABLE INSTRUMENT UNIT, ASSEMBLED ON TABLE AT END OF ROOM. OPERATES EITHER ON ENGINE OUTSIDE, OR ON A. C. LINE OF BUILDING.

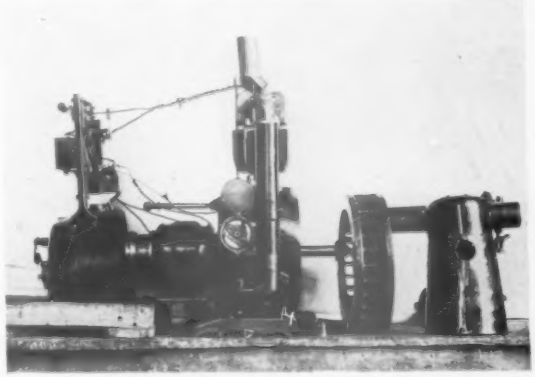


FIG. 15. DELCO ENGINE DISASSEMBLED EXCEPT AS TO WIRING.

shadows, as revealed by plates made in standard positions.

General Radiography: Chest: Gastro-intestinal and Urinary tract: Dental: Sinus, Mastoid, and Treatment: At this point in the course the students are assigned to these various radiographic rooms in smaller groups and apply the instruction they have

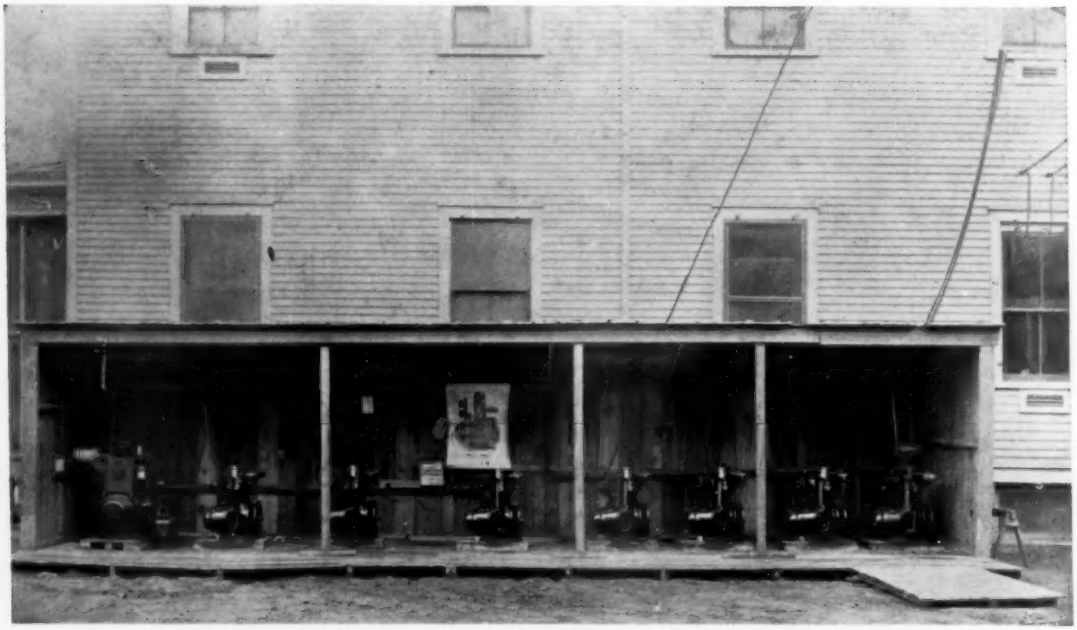


FIG. 16. DELCO ENGINES. NOTE LEADS FROM ENGINES TO SECOND STORY.

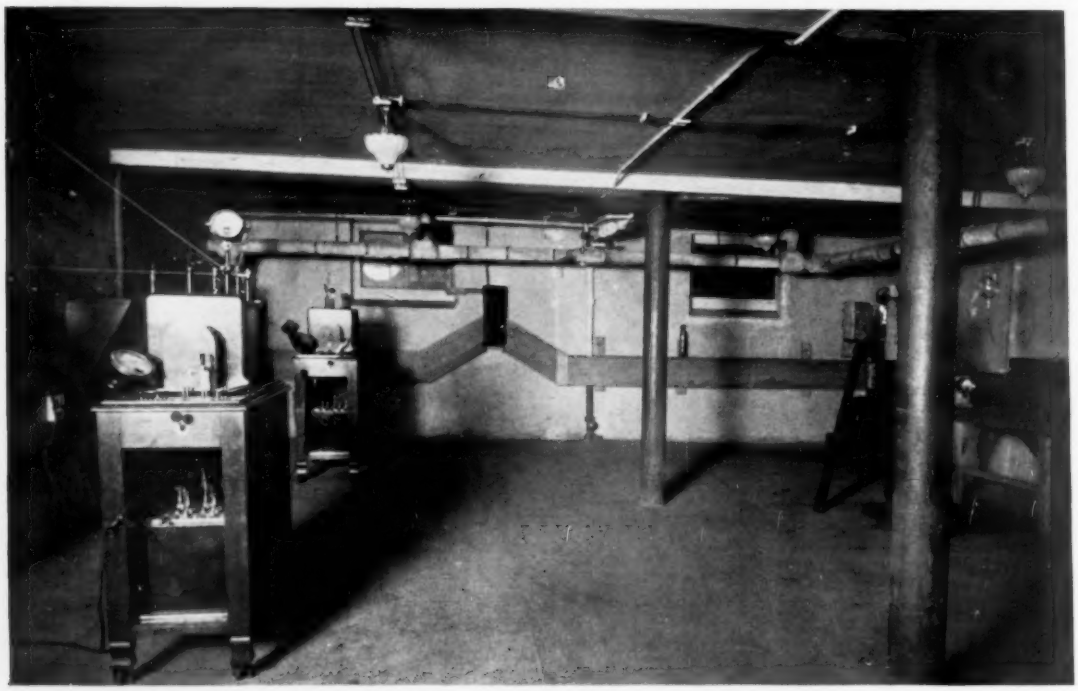


FIG. 17. COIL ROOM. PHOTOGRAPH SHOWS THREE OF THE FIVE INDUCTION COIL OUTFITS. LARGE ROTARY CONVERTER IN CORNER SUPPLIES DIRECT CURRENT.

received up to this time. In these rooms under the supervision of an experienced roentgenologist the student actually does practical radiographic and fluoroscopic work, adjusting the patient, making the exposure, and reporting the *x*-ray findings in the case.

View Box Rooms: The fluoroscopic and radiographic work occupy one section

be moved from their beds. This work is done with the standard Army Bedside *X*-ray Unit.

Bone Lesions: The work in this assignment is to be done in one of the view box rooms and includes a study of selected plates of actual bone lesions with special attention to fractures and bone and joint infections.

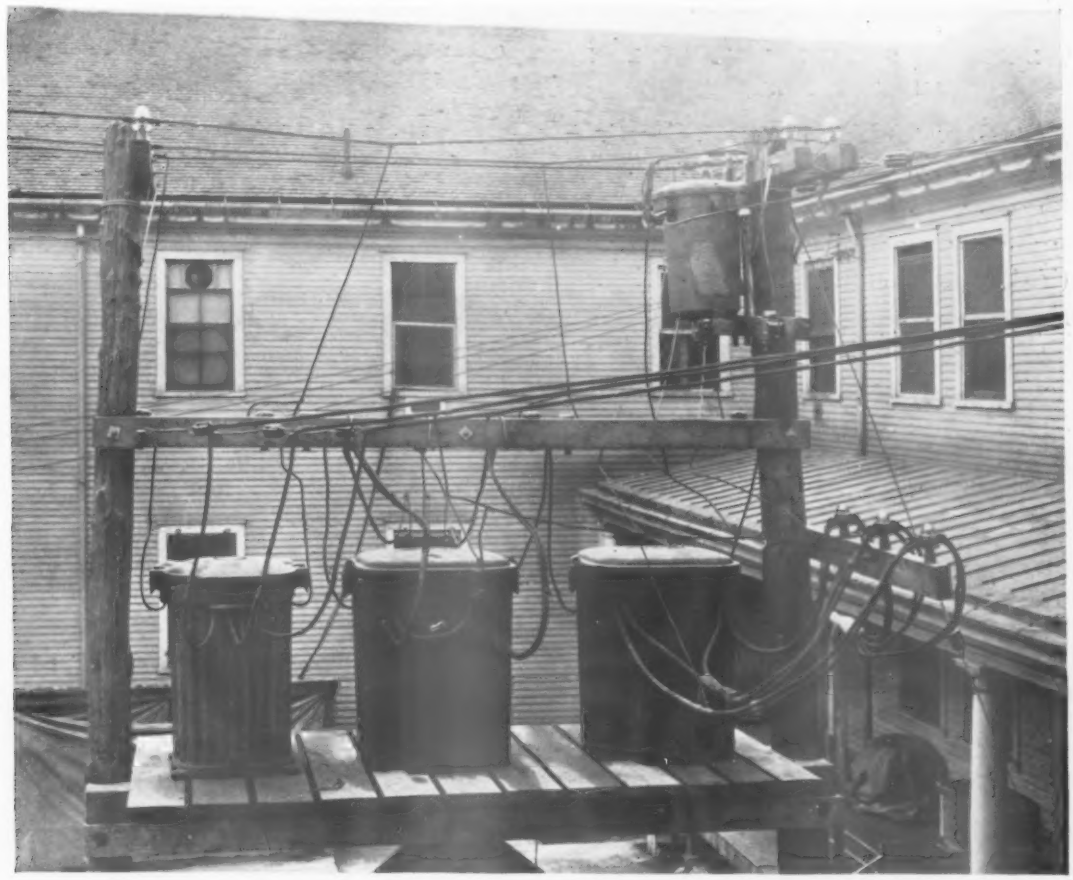


FIG. 18. STEP-DOWN TRANSFORMERS SUPPLYING POWER TO THE SCHOOL.

period of each day, the other being given to study of the plates made, as well as of selected plates of lesions of various parts of the body. This plate study is done under assignment to the view box rooms.

Bedside Unit: During this assignment the student officers are required to go from ward to ward, making the necessary fluoroscopic bedside examinations and also radiographs of fracture cases that cannot readily

Localization: During this assignment the medical officers are given individual instruction and drill in the use of the methods of localization that have been adopted as standard. The time allotted for this instruction in this school is twice as long as was given in former schools elsewhere.

Photography and Filing: This room is devoted to meeting the actual needs of the school in the way of making identification

photographs of the students and in making lantern slides for teaching purposes. A selected group of students from among the enlisted men will receive advanced instruction in photographic and developing room work. Another group will be assigned to filing plates and the keeping of records, becoming especially familiar with this part of the manipulator's work.

THE TWO MONTHS' COURSE

Outline of Instruction in Developing and Photography

Instructor: 2d Lieut. Fred O. Coe, S. C.; *Assistant Instructor:* Sgt. Walter W. Bennett, Med. Dept.

INDIVIDUAL LABORATORY EQUIPMENT
(To be checked during the first period.)

2 4 x 5 trays, 1 10 x 12 tray, 2 1-litre bottles, 1 thermometer, 1 hand towel, 1 negative rack, 1 8 oz. glass graduate, 1 16 oz. glass graduate, 1 Florentine flask, 1 black oilcloth apron.

FIRST PERIOD. *Dark Room Procedure. Loading Drill*

1. Inspection of Dark Room in Ward S.
2. Students take places assigned in 1–32. Check equipment.
3. Demonstration of leading photographic material by instructor.
4. Loading drill:
    1. Plate into envelope and carrier.
        a. Student opens plate boxes.
        b. Loads plates into envelopes.
        c. Examination instructor.
        d. Unloads plate.
        e. Loads into developing rack.
        f. Replaces plate into box.
    2. Double-coated film into envelope.
        a. Into envelope, same procedure as above.
        b. Into exposure holder, same procedure as above.
    3. Dental Films.
        a. Unwrap package and load into holders.
    4. Plate into cassette, demonstrated by instructors.
        a. Cassette without screen.
        b. Cassette with screen.
    5. Film into cassette, demonstrated by instructor.
5. Load plates required for exposure drill.
6. Load plates and films required for week's work.

Material Needed: For each student, box with plate, same with film, dental film, core plate developing rack, film developing rack, dental film holder, envelopes, film exposure holder, plates to be loaded for exposure drill and for week's work, material from exposure drill to be developed. For each instructor, cassettes, plates and films.

SECOND PERIOD—*Dark Room Procedure*

1. Talk on mixing developer and hypo, covering:
    a. Personal cleanliness.
    b. Cleanliness of utensils.
    c. Care in getting right amounts.
    d. Tables of weights and measures.
    e. Saving of test lot (1 pint each) of developer and hypo.
2. Calculation of amounts necessary for 1 gal. developer and 1 gal. fixing bath.
3. Each group of sixteen students to prepare 1 gal. fixing bath and 1 gal. developer (give each of six some water in flask and let each put one chemical into solution).
4. Each student takes 1 pint of developer and 1 pint of fixing bath and labels bottle.

Material Needed: Chemicals weighed out for 1 gal. developer.
Same for 1 gal. fixing bath.
Distilled water in water pails.
Labels.

5. Demonstration of action of ingredients in developer and fixing bath.
    a. Following solutions to be made up separately, each of strength of normal developer.
        1. Metol.
        2. Sodium sulphite.
        3. Hydrochinon.

* Many valuable suggestions were made by Mr. Willard B. Hodgson.

4. Sodium carbonate.
5. Potassium bromide.
6. Hypo.
7. Sulphuric acid.
8. Chrome alum.

b. Experiments with developer.
1. Exposed film in each. Action watched.
2. Exposed film, metol and sodium sulphite.
3. Exposed film, metol, sodium sulphite and sodium carbonate.
4. Exposed film, hydrochinon and sodium sulphite.
5. Exposed film, sodium sulphite and sodium carbonate.
6. Exposed film, sodium sulphite, sodium carbonate and KBr.
7. Exposed film in each of the following at the time:
a. Developer complete except for the KBr.
b. Developer complete.

c. Experiments with fixing bath.
1. Hypo and unreduced film.
2. Hypo and reduced film.
3. Hypo and sulphuric acid.
4. Chrome alum and sulphuric acid.

THIRD PERIOD—*Dark Room Procedure*

1. Talk on plate identification covering:
a. Writing on plate with lead pencil.
b. Use of lead numbers.
c. Making numbers from fuse or copper wires.
d. (Use of control spot in developing).

Lecture on judging development.

2. Demonstration by assistant instructors of correct development, each student developing four plates and two films correctly exposed (of a hand).
Procedure:
a. Demonstration by instructor.
b. Each manipulator gets developer, water, fixing bath, etc., ready. Temperature of developer 65° F.
c. Turn on ruby lights. Turn off white lights.

1. FIRST PLATE: *Normal Development*
1. Unload plate.
2. Mark plate with name, *station*, section.
3. Start development. Instructor watches time.
4. 1 minute. View by reflected and transmitted ruby light.
5. 2 minutes. View as in 4.
6. 3 minutes. View as in 4.
7. 4 minutes. View as in 4.
8. 5 minutes. Remove from developer, rinse in water, place in hypo.
9. Turn on white light at once, student watching progress of fixation. Wash and dry when completed.
11. Each plate examined.

2. SECOND PLATE: *Corrected Development. Independent Work*
1. Information to manipulators that it is correctly exposed.
2. Turn off lights and let them develop, not knowing time. At end of eight minutes turn on white lights and let them see results.

3. FIRST FILM: *Normal Development as in First Plate*

4. SECOND FILM: *Correct Development as in Second Plate. Independent Work*

5. THIRD PLATE: *Warm Developer*

Have developer warmer than normal. Give normal time. Note results.

6. FOURTH PLATE: *Cold Developer*

Have developer colder than normal. Give normal time. Note results.

Materials: 4 x 5 plates and 2 x 5 films, all correctly exposed. Method for

cooling and warming solutions. Each manipulator uses developer prepared during preceding day.

FOURTH PERIOD: *Dark Room Procedure*

1. Review on judging development.
2. Practice in developing and judging development.

FIRST PLATE. *Development Underexposure*

Put underexposed plate in developer. Observe time at which image shows up. Develop to normal time and observe results. (Immerse again into developer and give two minutes over normal.) Remove to fixing bath.

FIRST FILM. *Underexposure*

Procedure same as with First Plate.

SECOND PLATE. *Overexposure*

Develop to correct density regardless of time necessary.

SECOND FILM. *Overexposure*

Same procedure as with Second Plate.

THIRD PLATE. *Exposure unknown*

Develop to density giving diagnostic value.

THIRD FILM. *Exposure unknown*

Develop to density giving diagnostic value.

3. Put plates to wash and let them wash during quiz. Put to dry before leaving room. This procedure to take place each day.
4. QUIZ:
   1. What do you understand by an underexposed plate?
   2. What is an overexposed plate?
   3. What difference in the development of an underexposed plate?
   4. How would you judge correct development?
   5. Why is development apparently carried beyond the density desired in the finished negative?
   6. What are the stages in the appearance of the image in a normal exposure?

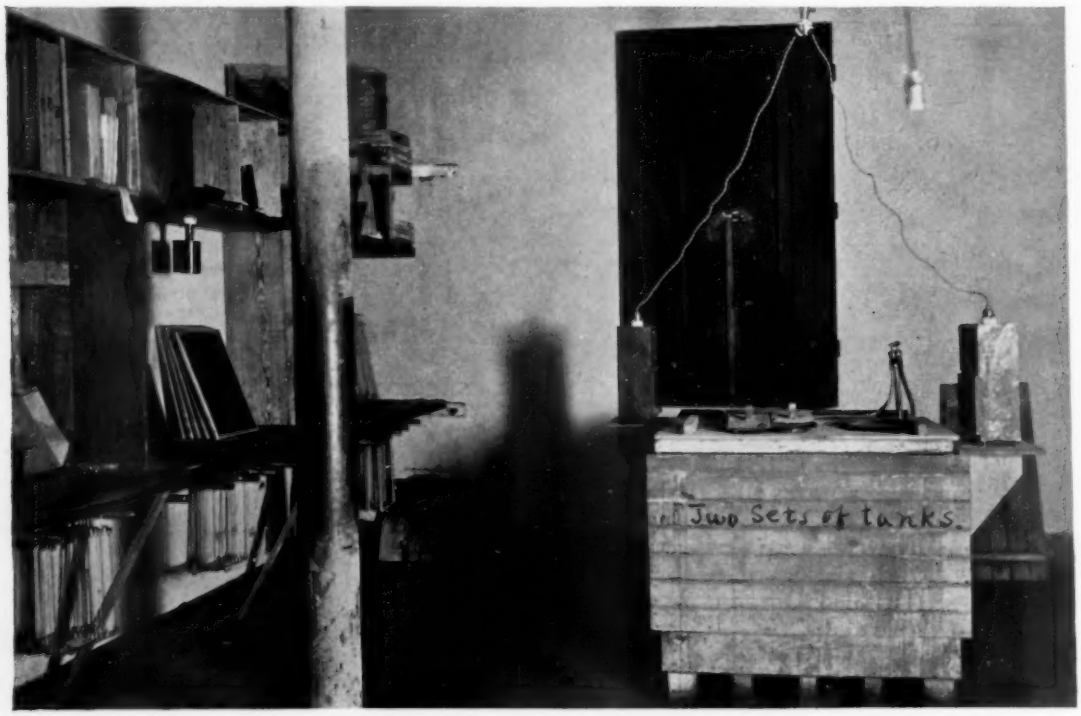


FIG. 19. MAIN DARK ROOM.

MATERIAL NEEDED FOR EACH MANIPULATOR

1 underexposed plate, 4 x 5 size, 1 overexposed plate, 4 x 5 size, 1 unknown exposure plate, 4 x 5 size, 1 underexposed film, 4 x 5 size (duplitized), 1 overexposed film, 4 x 5 size, 1 unknown exposure film, 4 x 5 size.

manipulator should have: 1 normally exposed 8 x 10 (or larger) plate and film, 1 underexposed 8 x 10 (or larger) plate and film, 1 overexposed 8 x 10 (or larger) plate and film.

SIXTH PERIOD. *Dark Room Procedure. Tank Development of Miscellaneous Material*

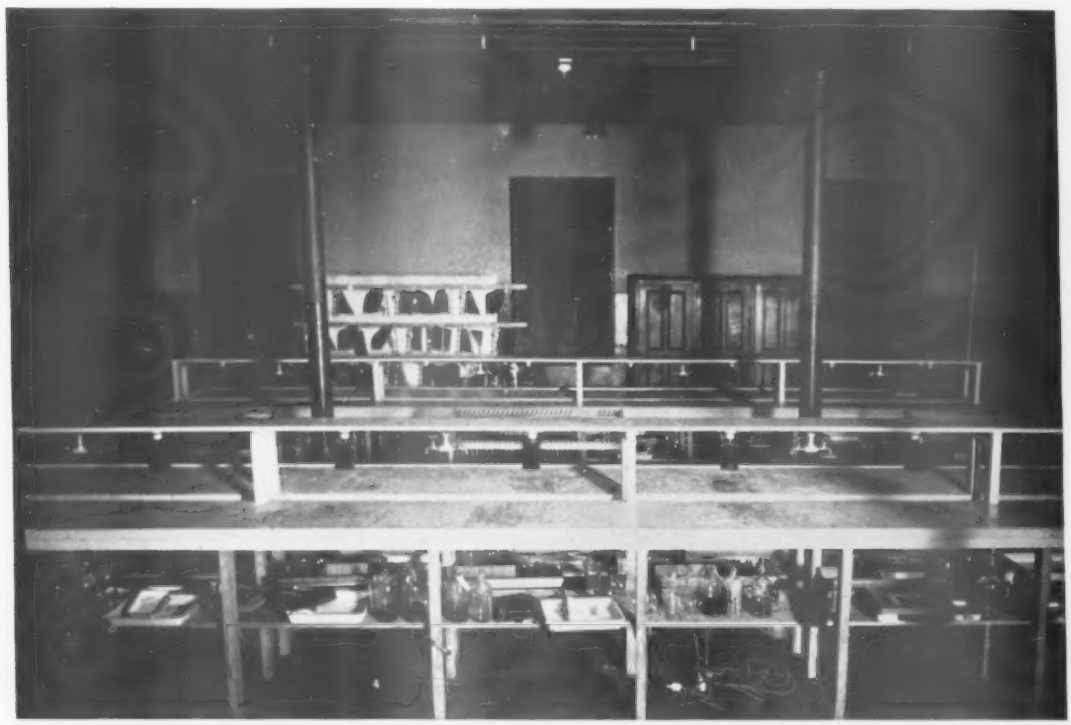


FIG. 20. DEVELOPING COUNTERS. NOTE INDIVIDUAL EQUIPMENT COMPLETE. COUNTERS WHITE. ALL LIGHT IN THIS ROOM WHITE AND RED, UNDER CONTROL OF INSTRUCTOR BY MEANS OF WALL SWITCHES.

FIFTH PERIOD: *Dark Room Procedure. Tank Development*

1. Brief talk on tank development.
2. Practice. Manipulators, in order, from each table, develop a film or plate. In the meanwhile all manipulators not at tanks can ask questions and be quizzed by the instructor. Quiz questions for week's work to be gone over.

MATERIAL NEEDED

Tank units. 6 gal. developer made with powders and 6 gal. fixing bath made with powders for each set of tanks. Each

Procedure—Give students material and let them proceed to develop with greatest speed and accuracy, having in view diagnostic value of negatives. Each group of six men to mix developer and fixing bath.

MATERIAL AT EACH STATION

1 doz. negatives of all sizes, including both plates and films, some coming from exposure drill, 1 pkg. dental films, developing racks for plates and films. For each group of six men: 2 pkg. developer, chemicals to make 2 gal. fixing bath. For class use: 16 gal. distilled water.

SEVENTH PERIOD. *Dark Room Procedure. Practice in Developing*

1. Explanation of work by instructor.
2. Student develops first film without any direction from instructor.
3. Negative examined by instructor.
4. Repeat same procedure for rest of the first plates or films.
5. Students develop last six without help.
6. Instructors examine day's work.

MATERIAL AT EACH STATION

1 doz. 4 x 5 films, all conditions of exposure, 1 pint developer, 1 pint hypo or fixing bath, plates from exposure drill.

EIGHTH PERIOD. *Dark Room Procedure*

1. Lecture No. 5: The combined effect of exposure and development on the quality of the negative.
2. Students develop plates simultaneously, the instructor announcing the various amounts of time necessary. The following are developed:
   1. Exposure one-tenth normal, development one-fourth normal.
   2. Exposure one-tenth normal, development normal.
   3. Exposure one-tenth normal, development twice normal.
   4. Exposure normal, development one-fourth normal.
   5. Exposure normal, development normal.
   6. Exposure normal, development twice normal.
   7. Exposure four times normal, development one-fourth normal.
   8. Exposure four times normal, development normal.
   9. Exposure four times normal, development twice normal.
3. Quiz at the end of period on all points brought out.

MATERIAL AT EACH STATION

3 4 x 5 films, exposure one-tenth normal, 3 4 x 5 films, exposure normal, 3 4 x 5 films, exposure four times normal.

NINTH PERIOD. *Dark Room Procedure. Negative Defects and Remedies*

Procedure:

1. Student Officer develops underpenetrated plate.
2. Student Officer develops overpenetrated plate.
3. Student Officer develops fog plate.
4. Student Officer develops plate showing motion.
5. Instructor demonstrates plate taken with emulsion against screen.
6. Instructor demonstrates plate taken with emulsion against glass.
7. Instructor reduces dense plate.
8. Instructor develops double-coated film showing crimp marks.
9. Instructor demonstrates other plate defects as hypo crystals on plate, air bubbles, dirt, grease, finger marks, etc.

MATERIAL:

Underpenetrated plate, overpenetrated plate, fog plate, plate showing motion, plate with emulsion against screen, plate with emulsion against glass, dense negative, reducing solution, plate showing other defects.

TENTH PERIOD. *Dark Room Procedure*

EXAMINATION

1. Students get plates ready for examination.
2. Instructors and assistant instructors examine plates and films developed by each student.
3. Oral quiz and chance to ask questions.
4. All plates turned in.
5. Check material at stations.

A Typical Set of Examination Questions

1. Give the structure and composition of the emulsion used in the *x*-ray plates.

What is meant by ripening the emulsion?

What is the difference in structure between a *duplitized* and a single-coated film?

What is the effect of exposure on the emulsion?

2. Give the formula for the developer used here.

Give the function of each ingredient and its effect on the plate.

3. Give the formula for the fixing bath used here.

Give the function of each ingredient and its effect on the plate.

4. How would you judge correct development?

How long would you fix a plate?

How long would you wash a plate?

Give directions for reducing an over-developed plate.

How could you dry a plate quickly for examination?

5. Draw an outline and label plans for a dark room. Describe plans, briefly.

X-RAY ANATOMY—POSITION DRILL —EXPOSURE DRILL

Instructor: Captain James W. Levering, M. C.; *Assistant Instructors:* Lieut. M. D. Baker, M. C., Lieut. A. O. Truelove, M. C.

Number of Students, 48. Duration of course, 2 weeks, as follows: Daily lecture to entire class, 1 hour. Daily laboratory period to one-half class, 2 hours. Written examination at the end of each week. (Note: In the laboratory the students work in pairs, using each other as patients.)

Apparatus Used: Anatomical charts, *x*-ray plates, blackboard, skeleton, two base hospital (large type) machines and tables with separate tube stands and two field outfits with the tube beneath the table, a large view box and a stereoscope.

First Lecture: Osteology as seen on *x*-ray plates. Types of bone; consideration of surfaces of the bones. Classification of eminences and depressions.

Composition of Bone: $\frac{1}{3}$ organic, $\frac{2}{3}$ inorganic. How alterations of the composition may be seen on the *x*-ray plate.

Structure of Bone: In detail.

Development of Bone: *Briefly.* Illustrate difference between intra-cartilaginous and intra-membranous. Stress laid on fact that cartilage is not converted into but is replaced by bone.

Action of osteoblasts and osteoclasts.

Growth of Bone: Long bone, short bone, flat bones. Discussion of epiphyses, the relation of the nutrient artery to time of ossification of epiphyses. Rules concerning the direction of the nutrient artery.

The Upper Extremity: Shoulder, girdle, scapula—its importance.

Scapula: Demonstration of body, head, neck, spine process, etc. Location of nutrient foramen. Osseous centers. Practical considerations. Clavicle—discussion of abduction. Description of the bone. Difference between the outer and inner articulation. Deltoid tubercle—its resemblance to callus. Nutrient artery. Osseous centers. Practical considerations. Injuries.

Humerus: Description of proximal end. Anatomical neck. Surgical neck. Osseous centers. The conical epiphyseal cartilage, time of union.

The Shoulder Joint: Ligaments, size of joint, the weak point, practical considerations. Displacements. (1) Anatomical factors in favor. (2) Anatomical factors opposed.

Second Lecture. Upper Extremity (cont.); Humerus (cont.): The shaft. Its shape. The rough surface for attachment of deltoid. The musculospiral groove. The location of the nutrient foramen. Anatomical facts to be considered in fracture of the shaft and in cases of non-union.

The Distal End: Description of condyles, articular surfaces, the fossa. The carrying angle. The osseous centers. The lower humeral epiphysis.

The Forearm: Its function. The axis of rotation in pronation and supination The ulna continuous with the humerus

acts mainly as support and serves as an anchoring part for the attachment of the muscles that move the radius which is continuous with the hand.

The Inter-osseous Ligament: Direction of its fibers. How force is thus transmitted from the radius to the ulna.

The Ulna: Description. Proximal end large and cancellous. The two processes and two articular cavities. Tubercles. Action of triceps and brachialis anticus. The shaft. Nutrient foramen. Sharp inter-osseous border. Distal end. Head, styloid, groove for extensor carpi ulnaris. Ossific centers. Practical consideration. Epiphyseal lines, fracture.

The Radius: Description. Proximal end. Head. Neck. Bicipital tubercle. Action of biceps. Shaft: Upper portion compact. Lower portion cancellous; nutrient foramen. Distal end: Description. Osseous centers. Epiphyseal lines. Fractures.

The Elbow Joint: Type, ligaments, the weak points, the shape of the bones, dislocations, disease, the extent of the capsule, osseous centers in and without the joint, time of appearance as well as union. The prominent internal condyle of humerus and the prominent olecranon not in the capsule. Bursa.

The Carpus: Developed from single osseous center with the exception sometimes of the scaphoid. Scaphoid *bipartem* peculiarities of the shape and arrangement of the different carpal bones. Time of appearance of ossification.

The Inferior Radio-ulnar Articulation.

The Radio-carpal or Wrist Joint: Emphasis laid on the ridge on the articular surface of the radius, the triangular fibro-cartilage; the attachment of the internal lateral ligament to the styloid of the ulna. The annular ligaments and the tendons. Importance of epiphysis at wrist.

The Metacarpus: Arrangement, description of the shaft, extremities, osseous centers, epiphyseal lines; peculiarity of the first metacarpal. Practical considerations.

The Phalanges: Description, osseous centers, epiphyseal line, sesamoid bones. The Mid-carpal Joint. The phalangeal joints.

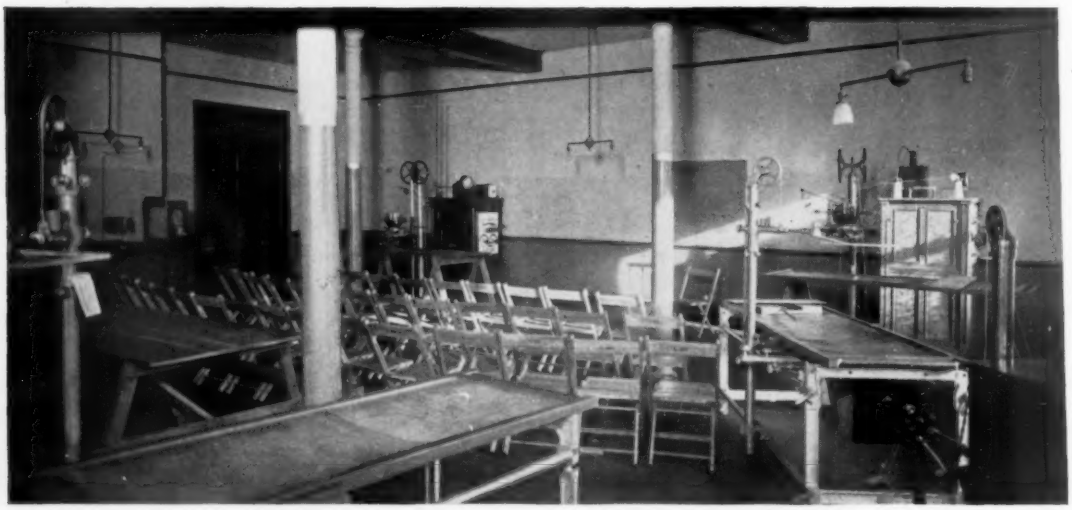


FIG. 21. POSITION AND EXPOSURE DRILL ROOM.

Third Lecture. The Lower Extremity: Consideration, designed to bear weight and for locomotion. Pelvic girdle. Innominate (ilium—ischium—pubes) united in acetabulum by cartilage and ossified by sixteen years.

Os Ilium: Description, importance of the crest, the spines, groove for reflected tendon of rectus femoris, articular surface for sacrum and ossific centers.

Ischium: Description, body, groove, the spine, the tuberosity, the bursæ in proximity, ramus, ossific centers.

Pubes: Description, body and rami, ossific centers, description of the acetabulum, ossific centers, practical considerations.

The Femur: Description, proximal end, description of the head location of ligamentum teres. The angles of the neck, the trochanters, digital fossa, etc., Location and direction of the nutrient arteries in the neck, Shenton's line, horizontal lines.

The Hip Joint: Type, ligaments, location and function, extent of the capsule, practical considerations, great security, dislocations, fractures, disease—frequent and grave, anatomical reasons, coxa valga and coxa vara.

The Epiphysis of the upper end of the femur. Time of appearance and of union.

Fourth Lecture. The Femur: The shaft, description. The distal end, description. Markings of the condyles. The plane of articulating surfaces. The osseous centers. The epiphyseal line.

The Patella: Sesamoid in origin. Its function. Description. Development.

The Fibula: Description, external malleolus, ossific centers. Epiphyseal lines.

The Tibia: Description. Nutrient canal. Upper end. Articular surfaces. Bifid spine. Patellar tubercle. Epiphyseal lines. The grooves on the tuberosities. Internal malleolus.

The Knee Joint: Type, ligaments and accessories. Bursæ. Location and communications with the joint. Practical considerations: (1) Anatomical factors favoring dislocation. (2) Anatomical factors opposed to dislocation. Relation of capsules to the epiphyseal lines. The chief seats of growth in length of the lower limb. Disease. Loose bodies. Hilton's Law. Genu Valgum and Varum.

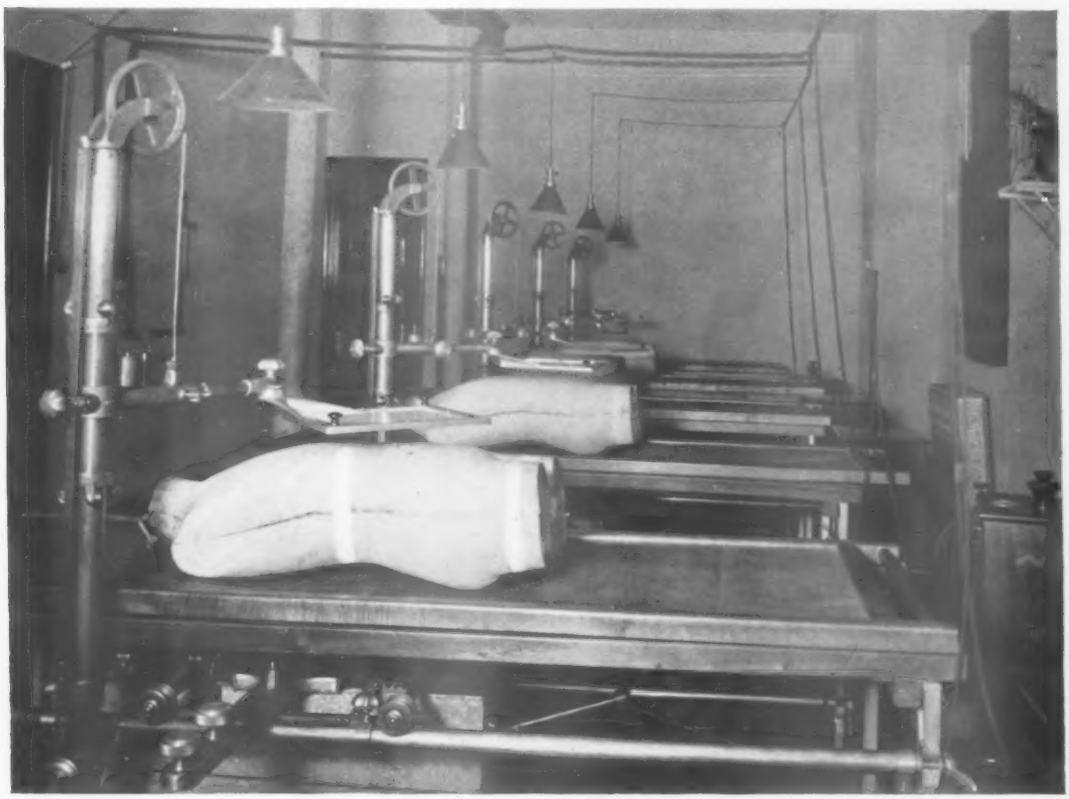


FIG. 22. LOCALIZATION ROOM.

The Ankle Joint: Type, ligaments. Capacity of synovial sac. Practical considerations.

The Foot: Intended for support and locomotion. Key to its pathology, a knowledge of the bony structures. The internal and external division of the bones of the foot.

The Tarsal Bones: Description. Peculiarities and practical considerations. Time of appearance of osseous centers. Epiphyseal line of os calcis. The sub-astragaloid joint.

The Metatarsal Bones: Description, development, epiphyseal lines. The phalanges, description, osseous centers, sesamoid bones, practical considerations. Flat foot, injuries.

Fifth Lecture. The Vertebral Column: Consideration, composed of many pieces, united by tough fibro-cartilaginous disks, by which the force of shock is broken and the great range of movement is distributed among many joints. Its fixed points, the curves, the numerous prominences.

A Typical Vertebra: Diagram, body of centrum and the arch (2 pedicles, 2 laminæ, 7 processes.) Consideration, spongy character of the body. Interlocking of articular processes. Position of spinous and transverse processes.

The Cervical Vertebræ: Characteristics. The peculiar cervical vertebræ.

The Dorsal Vertebræ: Characteristics. The peculiar dorsal vertebræ.

The Lumbar Vertebræ: Characteristics. The peculiar fifth lumbar vertebra.

The Sacrum: Description. Osseous centers. Anomalies. The lumbro-sacral and the sacro-iliac joints.

The Coccyx: Description. Practical considerations. The spine as a whole. Fracture, dislocations, diseases and postural changes.

The Ribs: Description. Head, neck, tubercle, angle and groove, the peculiar ribs.

The Sternum: Description. Manubrium, gladiolus, xyphoid, The angle of Lewis, osseous centers.

Sixth Lecture. The Skull: Consideration. The bony framework of the head, enclosing vital structures, supported upon the summit of the vertebral column. Composed of a series of flattened and irregular bones which with one exception are immovably joined together.

The Cranium: Development of the inner and outer tables. The difference in the structure of the two tables. The markings on the inner table. The diploic space. Points of thinness and thickness.

The Frontal Bone: Description. Practical consideration. The frontal sinuses.

The Parietal Bones: Description.

The Occipital Bone: Description.

The Temporal Bones: Description. Practical consideration. The mastoid.

The Sphenoid Bone: Description. Practical consideration. The sella turcica and the sinuses.

The Ethmoid Bone: Description. Practical consideration. The sinuses. The crista galli. Practical considerations of the cranium, the sutures, the meningeal vessels, the venous sinuses, surgical landmarks, glabella, inion, pterion, etc.

The Face: Bones, six pairs and two single bones. Brief description with emphasis on location of the different bones. The boundary of the orbit, the nose, the mouth. The superior maxilla, practical considerations. The maxillary sinus. The teeth. The inferior maxilla: Description. Practical consideration. Dislocation. Fractures.

Seventh Lecture. Intra-thoracic Viscera: The Thorax, description. The piston action of the diaphragm. Changes in shape of the thorax due to the disturbance of this action.

The Diaphragm: Description. Manner of its contraction. The muscular fibers. The regional anatomy. The lymphatic supply.

The Pleuræ: Closed sacs. Serous membrane. Negative pressure. Distribution. Meaning of mediastinal, interlobar, diaphragmatic, pleura. The costo-phrenic angle. The lymphatic supply.

The Trachea: Regional anatomy. Points

of constriction. Level of bifurcation. The main bronchi: Difference between right and left. The bronchial tree. Discussion of the distribution, particularly of the apex. The paravertebral, the 1st and 2d interspace bronchi. The anterior and posterior divisions throughout.

The Lungs: Difference between right and left. The root structures. The course of the main fissures and the accessory fissures on the right. Variations. The lobes. Upper and lower. Anterior and posterior, considerations. The lung unit. Lobule. The terminal bronchus. The peribronchial structures. Discussions and diagrams showing course of artery, veins and lymphatics along the bronchus and the distribution at the alveoli and air sacs. Cross section anatomy of the lung structures.

The Heart: Position. The normal curves. The pericardium. The Arch: Regional anatomy. The Thymus: Regional anatomy. The Thyroid: Regional anatomy.

Eighth Lecture. The Alimentary Apparatus:

Consideration: The alimentary canal and certain accessory organs. The canal a musculomembranous tube about 36 ft. in length extending from mouth to anus. Lined throughout by mucous membrane.

The Esophagus, 9 inches long, 1 inch diameter, flattened, gullet relations to adjacent structures. Point of constriction. Diverticulum.

The Stomach: Discuss the differences in position and shape between the stomach seen by *x*-ray examination and that described in anatomies.

Capacity: Size and shape. The importance of the contents and the pressure of surrounding structures. Regional anatomy.

Description: Pars cardiaca, pars media and pars pylorica. The pyloris, description.

The Duodenum: Description, 3 portions. Peculiarities of the 1st portion or cap. Relation to the gall bladder. The 2d and 3d portions. Position of the fixed duodenum. The ligament of Trietz. The ampulla of Vater.

The Jejunum and Ilium: Structures. General distribution. The iliocecal valve. Meckel's diverticulum.

The Large Intestine: Difference in structure and action from those of the small intestine.

The Longitudinal Bands. Haustri Coli. The fixed and the movable points.

Cecum: Appendix, hepatic flexure, splenic flexure, sigmoid.

The Accessory Organs: The teeth, salivary glands, liver, gall-bladder and pancreas.

Ninth Lecture. The Genito-Urinary Tract:

The Kidneys: Location and regional anatomy. Kidney structure. Description of normal kidney pelvis, variations within the normal.

The Ureters: Course. Regional anatomy. Points of constriction. The Bladder. Description.

Tenth Lecture. Anatomical Landmarks as Applied to Localization. The course of the principal arteries, veins, and nerves in the extremities is demonstrated upon the living subject and by means of charts. The boundary of joints is likewise demonstrated.

Charts of cross-section anatomy of the thorax and the abdomen are demonstrated with a view to instruct the student as to the manner of determining the depth of the various organs from the skin landmarks.

OUTLINE OF LABORATORY WORK

1st Laboratory Period: Drill in principles of position and exposure. Adjustment of tube above and below the table.

2d Laboratory Period: Position and exposure drill of upper extremities.

3d Laboratory Period: Criticism of plates taken on previous day and quiz in anatomy of same.

4th Laboratory Period: Position and exposure drill, lower extremity.

5th Laboratory Period: Criticism of plates taken on previous day and quiz in anatomy of same.

6th Laboratory Period: Position and exposure drill in spine.

7th Laboratory Period: Criticism of plates taken on previous day and quiz in anatomy of same.

8th Laboratory Period: Position and exposure drill, head.

9th Laboratory Period: Criticism of plates taken on previous day, and quiz in anatomy of same.

10th Laboratory Period: Visceral positions and quiz in anatomy of visceral plates.

REMARKS

In the laboratory an effort is made to combine truly the subjects in *x*-ray anatomy, exposure and position drill. The laboratory keeps abreast of the lectures.

In the laboratory the students work in pairs, one acting as subject while the other acts as operator.

The standard positions and exposure tables as given in the X-Ray Manual are followed throughout.

The student is made to repeat his plate until a satisfactory one is turned in.

The plates are used not only to criticize faults in position and exposure but as well to demonstrate the anatomy of the various parts.

Weight-bearing lines, parallel joint lines, etc., are marked on the plate.

A TYPICAL ANATOMY EXAMINATION

1. What is the capitellum?
2. Discuss the extent of the capsule of the hip joint upon the neck of the femur.
3. Describe (preferably by diagram) a typical vertebra.
4. What is the direction of the nutrient artery in the clavicle, the femur, the radius and the first metacarpal.
5. (a) What bones comprise the internal set in the foot?
   (b) Indicate the location of the epiphyseal line on the os calcis.
6. What is the time of appearance of the osseous centers at the upper end of the femur.
7. (a) Where should the central ray enter in an A. P. of the shoulder; an A. P. of the hip; an A. P. of the knee; a lateral of the elbow?
   (b) What is the time of exposure at 5″ spark gap, 40 ma. 20″ distance for these regions?
   (c) What direction is the shift for stereoscopic examination of the femur? Of the forearm?

8, 9, 10. On plates A, B, and C name the anatomical structures marked.

LOCALIZATION OF FOREIGN BODIES

Instructor, Captain E. S. Blaine, M. C.

The course of instruction in localization was intensely practical, and, as in other phases of the work, was based on the advice of those in authority at the front. A glance at the schedule of this course will show what methods were taught, all of which have been described, both in the U. S. Army X-Ray Manual and in THE AMERICAN JOURNAL OF ROENTGENOLOGY, so need not be repeated here.

Table drill, the first laboratory step,

SCHEDULE OF PERIODS IN LOCALIZATION COURSE

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1st week	1 Table Drill	2 Fixed Angle Method, Lecture and Practice	3 Fixed Angle Method, Practice	4 Parallax Method, Nearest Point Method, Lecture and Practice	5 Parallax Method, Practice	Examination
2nd week	6 Hirtz Compass Plate Method, Lecture and Practice	7 Hirtz Compass Plate Method, Plotting and Setting Compass	8 Hirtz Compass Screen Method, Plotting and Setting Compass	9 Eye Localization, Lecture and Practice	10 Eye Localization, Plotting and Reporting	Examination

Each period, 2 hours daily, 5 days each week—total of 20 hours.
Classes of 24 students, 4 to each table.

consisted of taking down and reassembling the table, after a very definite and systematic manner, a very important procedure, for the reason that practically all the work with the table had to be done in darkness. The drill made the student familiar with each part and its function in relation to other parts of the apparatus. Each student had to qualify in this drill before going farther in the course. The accompanying photograph shows five of the six complete fluoroscopic outfits of this laboratory. The plate methods were practiced in another operating room.

BONE LESIONS, TRAUMATIC AND PATHOLOGICAL—FRACTURES AND DISLOCATIONS

Instructor: Major Wm. H. Stewart, M. C.; *Assistant Instructor:* Capt. J. J. Clark, M. C.

LECTURE NO. 1

General Considerations: Definitions and varieties. Methods of examination. Advantages and disadvantages of the fluoroscopic method. Advantages and disadvantages of the roentgenographic method. Advantages of the combined methods with standardization of technique. Advantages and disadvantages of using the tube above and below. Necessity of immobilization. Importance of examining in more than one position. Value of the stereoscopic method. Importance of numbering roentgenograms and designating which side of the body examined. Consideration of the patient during the examination following the cardinal rule of a minimum amount of disturbance; adjusting the apparatus to the patient rather than the patient to the apparatus. Effect on bone of high and low speed projectiles. Effect of splints. Bone repair in fractures. Importance of fractures involving joint surfaces. Care in interpreting multiple lesions. Recognition of gas infection. Bedside examination.

Proper procedure in conducting a roentgen department in a military hospital. Organization of staff. Attention to details. Encouragement of daily consultations in the roentgen department.

STANDARDIZATION OF REPORTS, ADOPTING THE FOLLOWING FORM:

Roentgenographic examination reveals a { Single or Multiple } { Complete / Incomplete / Comminuted / Impacted / Fissured / Depressed / Perforatory / Diastatic } Fracture of the { ..... side / ..... part }

The line of fracture is { Irregular / Transverse / Longitudinal / Oblique / Spiral / "T" shaped / Stellate } And extends { ..... cm. / from ..... / bony landmark } { Downward / Inward / Upward / Outward } To about ..... cm.

The Fragments are { In good alignment / Overlapping to the extent of ..... cm. / Angulated to the extent of ..... cm. }

The { Upper / Lower } Fragment is displaced { Upward / Downward / Inward / Outward }

LECTURE NO. 2

Fractures and Dislocations of the Upper Extremities: Importance of differentiating between the normal epiphyseal lines and those produced by fracture. Common fractures and dislocations of the phalanges, metacarpals and carpals. Importance of recognizing rotation in dislocation of the semilunar. Varieties of Colles fracture. Importance of recognizing a disturbance of the normal relation between the styloids of the radius and ulna and the tilting of the lower fragment backward. The difficulty in proper replacement of the fragments in fractures of both bones of the forearm, and the value of the re-examination after reduction.

Roentgen consideration of the different varieties of fractures and dislocations around the elbow joint. The importance of examination in two positions, even when the forearm is placed in acute flexion. Dangers of musculospiral paralysis and pseudarthrosis in fracture of the middle third of the humerus.

Study of the common fractures and dislocations at the shoulder. The importance of roentgen examination after trauma of the shoulder when clinical signs of fracture are missing, as in fracture of the greater tuberosity of the humerus. Emphasis laid

on the value of the stereoscopic method of examination of the shoulder, including the scapula.

LECTURE NO. 3

Fracture of the Skull: Consideration of the normal skull as a whole. The common sites for fracture. The tendency of fractures to replace themselves. Recognition of the two varieties of fractures, i.e., those in which the bony lesion is of no importance except as a clue to the site of serious lesions of the soft parts as in fissured fracture of the vault, and those where the bony lesion is of importance where fragments of bone produce pressure on the vital structures, such as in depressed or penetrating fractures. Frequency of fracture of the vault involving the base; causes. The different varieties of fracture. The importance of a complete examination with consequent ability to make a positive negative diagnosis. Emphasis paid to the rule of a minimum amount of disturbance of the patient in these cases. Bleeding from the ear, nose or mouth, laceration of the scalp, hematoma or paralysis as a clue to the site of the lesion. Importance of immobilization. Details of the technique used in examination of the frontal, lateral, occipital and basilar regions. The necessity of recognizing the normal suture markings and the lines cast by the meningeal grooves on the inner table, also those cast by the diploëtic spaces between the tables of the skull, with the differentiation between these markings and those cast by fracture. Value of the stereoscopic method of examination of these lesions.

FIG. 23. FIRST VIEW, PLATE READING ROOM.

Fractures of the facial bones and the difficulty of recognition in the roentgenograms. Technique to be used in fractures of the malar bones and the zygomatic arch. The frequency of fracture of the lower maxilla; the common sites. The technique in the proper examination of these lesions, espe-

cially those of the condyle. The extensive comminuted fractures of the jaw from high speed projectiles; the effect usually on the exit side.

LECTURE NO. 4

Fractures and Dislocations of the Spine: The importance of a proper conception of the normal, and the interrelation of the normal bony landmarks in the upper cervicals. The proper technique for examination in injuries to the atlas and axis. The danger of moving the patient in all spine injuries. The frequency of the anterior fracture-dislocation of the cervicals and the importance of obtaining a lateral without turning the patient on his side. How to overcome the difficulties in obtaining proper detail of the seventh cervical. The infrequency of fracture or dislocation of the upper or mid-dorsals. Consideration of the common crushing fractures and lateral fracture-dislocations of the lower dorsals and lumbars. The importance of the stereoscopic examination and the lateral roentgenogram in these lesions. The necessity of obtaining good bony detail in the interpretation of fracture of the transverse processes. The anomalies of the fifth lumbar with recognition of sacralization.

Fracture of the Ribs: Importance of stereoscopic examination. The frequency of emphysema of the soft tissues from a punctured lung by a fragment of fractured rib.

Fracture of the Pelvis: Causation and common sites. Necessity of examining the entire pelvis. Fracture of the acetabulum.

LECTURE NO. 5

Fractures and Dislocations of the Lower Extremities: Consideration of the different varieties of fracture of the neck of the femur and dislocation of the hip and recognition of same. The technique of the stereoscopic method of examination and the value of the oblique roentgenogram of the hip with instructions how properly to obtain same. The necessity of a comparative study of the normal hip.

Fractures of the Shaft of the Femur: The importance of the lateral; the difficulty of replacement and the necessity of a roentgen control after replacement. The value of bedside examination where extension is being used. Obtaining the lateral without disturbing the patient.

Varieties of fracture of the lower third of the femur and dislocations at the knee. Fracture of the patella; rupture of the ligamentum patellæ and fracture of the tubercle of the tibia.

Varieties of fracture of the upper third of the tibia with emphasis on those involving the joint surface. Importance of comparative studies. Fracture of the middle third of the tibia with necessity of examining the entire leg on account of the frequency of fracture of the upper end of the fibula accompanying torsion fracture of the tibia. The difficulty of the surgeon in properly reducing fractures of both bones of the leg and the necessity of roentgen control. Consideration of the common fractures of the tibia and fibula in the lower third. The importance of disturbance to the weight-bearing line, most frequently produced by the outward dislocation of the astragalus accompanying these injuries. The necessity of calling the attention of the surgeon to this dislocation. Consideration of the method of production and varieties of fracture of the tarsals, especially the os calcis and scaphoid. The technique for the examination of the tarsals, metatarsals and phalanges, especially the lateral, and the frequent fractures and dislocations of these bones. Fracture of the sesamoid bones at the distal end of the first metatarsal.

LECTURES ON BONE PATHOLOGY

LECTURE NO. I

Study of the normal bone structure in long bones as seen roentgenographically with consideration of the component parts, namely, the epiphysis, epiphyseal cartilage, medullary canal, cortex and periosteum,

and the peculiar normal formation in flat bones.

The importance of being able to differentiate roentgenographically between benign and malignant lesions in bone. Necessity of a clear and detailed clinical history in each case. The value of diagnosis by analysis, especially pathology in the long bones. The five cardinal points to be considered in roentgenographic diagnosis by analysis, i.e.,

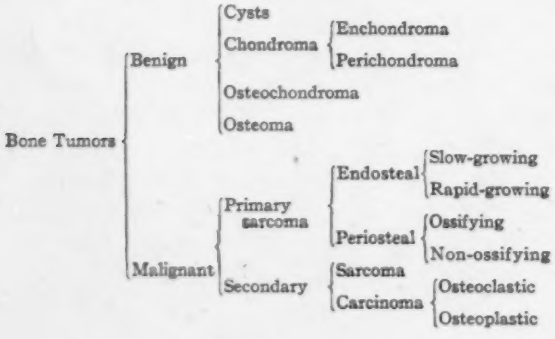
1. Point of origin
2. Production or destruction
3. Expansion or non-expansion
4. Condition of the cortex
5. Invasion or non-invasion

Illustration of the practical application of this method in the differentiation between benign and malignant growths in the long bones such as bone cysts, Brodie's abscess, and a slow-growing endosteal sarcoma. Roentgenographic changes in lesions of the flat bones. Difficulty of diagnosis after operative interference.

LECTURE NO. 2

General pathological and roentgenographical consideration of bone tumors. Importance of clinical history. Necessity of knowing the age and sex of the patient. Special value of roentgenographic diagnosis by analysis.

Classification with explanation:



LECTURE NO. 3

Bone Cysts: Most commonly seen in the long bones; observed most frequently between the ages of seven and fifteen years; occur in adults. Two forms, unilocular and multilocular. Particularly susceptible to fracture; often presence is unsuspected until trauma occurs. Roentgenographic analysis: Point of origin usually in the medullary canal; occasionally in the cortex; there is some destruction from a slow-growing expansion; no production is present unless from repair of fracture through the cyst wall; the cortex is thinned but intact; there is no invasion. The walls of bone cysts are as a rule sharply defined.

Chondroma: Two forms, enchondroma and perichondroma.

Enchondromas are cartilaginous growths which may or may not be cystic. Most commonly seen in the long bones near the epiphyseal cartilage; frequently in the metacarpals. May be multiple. History of a slow-growing tumor. Roentgenographic analysis: Point of origin usually medullary; there is no production unless trauma has occurred; expansion is present; the cortex is thinned but remains *intact.* There is no invasion. Attention to the difficulty of differentiating between a bone cyst and an enchondroma; surgically, however, it is not important as both are benign.

Perichondroma: The true form is most commonly seen involving the phalanges. Consists of a circular-shaped mass of hyaline cartilage with concentric or irregularly shaped deposits of bone at the periphery of the mass. They are periosteal in origin extending outward into the soft parts, often between the toes or fingers. Some production in the growth occurs; the cortex may become thinned and eroded secondarily.

Osteochondroma: Tumor having a history of slow growth, usually cauliform in shape with a broad base or a pedicle of bone and an expanding periphery which consists of a varying amount of cartilage. Most commonly seen at the upper end of the humerus or the lower end of the femur. Arises, as a rule, near the epiphyseal line and is directed away from the joint. Roentgenographically the point of origin is from the cortex. The normal cortical lines extend out into the bony portion of the growth.

There is no invasion. As ossification becomes complete, they become true osteomas.

Osteoma: Numerous varieties. Most common are the completely ossified osteochondroma and the single and multiple exostosis. In the first we have all the characteristics of the osteochondroma with no cartilage present; they are seen most frequently at the ends of the diaphysis near the epiphyseal line; the upper end of the humerus and the lower end of the femur are most commonly involved. They are cortical in origin with a broad base or united to the shaft by a pedicle. The normal bone markings extend out into the bony growth. There is production with no expansion or invasion. The history is of a slow-growing tumor.

Exostoses are single or multiple bony tumors which grow out from the cortex at right angles to the shaft or follow the course of a tendon. The normal bone markings always extend out into the growth. The single form is usually the result of some local irritation such as the spurs on the under surface of the os calcis, anterior surface of the tibia and the inner surface of the femur. Multiple exostoses are congenital, involving all bones, and have a distinct family trait.

Osteomas of the long bones are called cancellous while those of the flat bones, such as the skull, are extremely dense and known as ivory osteomas.

LECTURE NO. 4
Malignant Tumors of Bone

General Considerations: Explanation of classification. The difficulty of differentiating roentgenographically between sarcoma and carcinoma. Importance of clinical history; in this differentiation carcinoma of bone always being secondary and as a rule located near the nutrient artery. Tendencies of all malignancy to destruction and invasion. The three sarcomas showing bone production: osteosarcoma, slow-growing endosteal sarcoma and ossifying periosteal sarcoma. Dependency of the activity of sarcoma on the character of the cell, round-celled sarcoma being most malignant; spindle-celled sarcoma not so active. Frequency of growths showing both cells. Malignancy of bone does ***not*** extend into and involve a joint.

Study of Slow-growing Primary Endosteal Sarcoma (commonly known as giant-celled sarcoma): Two varieties; the non-malignant and the malignant. The non-malignant is known as myeloma, myeloid sarcoma, non-malignant giant-celled tumor, and recently Barrie describes a hemorrhagic osteomyelitis which comes under this class. Roentgenographically, the point of origin is in the medullary canal. They are slow growing, consequently we have expansion with pressure destruction, thinning of the cortex with no invasion; the cortex remains *intact*. The tumor has a tendency to grow in all directions rather than up or down the shaft. It does not have a sharp line of demarkation as a bone cyst. The *malignant* form of giant-celled sarcoma gives a history of slow-growing tumor seen most frequently in the lower ends of the radius, ulna and tibia. Roentgenographically it is central in origin with a slow pressure destruction usually in all directions. There is expansion with a thinning of the cortex which is perforated. The periosteum throws down protective layers of bone as the tumor invades the soft parts, producing what is known as trabeculation. These tumors as a rule contain spindle as well as giant cells. Differentiation from the non-malignant form is based on the perforated cortex, the invasion of the soft parts and the trabeculation; the latter places them in the class of sarcomas where production occurs.

Osteosarcoma comes under the class of slow-growing endosteal sarcomas. They usually arise from the cortex. The point of origin is sometimes difficult to ascertain. There is marked production with some destruction of the shaft, very little, if any expansion. The cortex is destroyed and replaced by the bony growth and there is invasion of the soft parts. Often we have

periosteal production as well; when this occurs, the bone is laid down perpendicular to the shaft. Careful examination of the roentgenograms with a magnifying glass is often necessary to ascertain the character of the production. The history is of a slow-growing tumor which frequently reaches enormous size.

Consideration of the Rapid-Growing Endosteal Primary Sarcomas: History of rapid growth. Roentgenographically the point of origin is in the medullary canal. There is rapid destruction, usually toward one side and no expansion. The cortex and periosteum is swept away and there is invasion in the soft parts. Pathological fracture frequently occurs in the remaining portion of the shaft opposite the growth. The tendency is an extension toward the surface of the bone rather than up and down the shaft and there is no sharp line of demarkation. They are usually of the round-celled type.

Periosteal Primary Sarcoma (ossifying and non-ossifying form):

Ossifying Form: Bone-producing tumor, most frequently observed at the lower end of the femur and humerus. Develops with considerable rapidity. Roentgenographically it is seen to arise from the periosteum. Characterized by a production of bone which is laid down in striæ always perpendicular to the shaft giving a "sunburst" effect, the ends of these productive lines being free and not connected; no expansion is present. The cortex is eroded as a late manifestation. There is invasion of the soft parts. Importance of differentiation between this tumor and a simple periosteitis where the periosteal production is laid down in striæ parallel to the shaft and a late manifestation of syphilis where the periosteal production is at right angles to the shaft but the free ends of the striæ are connected or looped giving a "lace-work" effect.

The Non-ossifying Form is rare, characterized by a tumor arising from the periosteum and extending out into the soft parts; there is very little ossification present; at times, with a glass, fine bony striæ which have all the characteristics of the ossifying form can be seen arising from the periosteum. Some destruction of the cortex occurs late in the lesion.

Secondary Malignancy of Bone: General considerations: Importance of clinical history, including age and sex; ascertaining the primary lesion and, if possible, the pathological findings. The tendency of all bony metastases to assume the histological characteristics of the primary growth.

Secondary Sarcoma: It is almost impossible to differentiate between this condition and a secondary carcinoma unless one knows the pathological findings of the primary growth. It is necessary to have a clear clinical history, with age and sex of patient, in making the differentiation.

Carcinoma of Bone: Always secondary. The necessity of a history of the primary growth. Importance of sex and age. Two forms, the osteoclastic and osteoplastic.

Osteoclastic Carcinoma of Bone is a metastasis which is a rarefying malignancy and follows most frequently a soft medullary primary growth such as is frequently seen in the breast or uterine appendages of the female. Roentgenographically it is observed most frequently in the bones of the pelvis, the spine and the femurs. The point of origin is always medullary. There is distinct rarefaction and absorption, the bone losing its normal outline. There is no production or expansion. Destruction is extensive. The cortex may be thinned but it is usually destroyed and there is invasion of the soft parts. The growth does not involve the joint surfaces.

Osteoplastic Carcinoma of Bone is a metastasis following a primary growth of a scirrhous character, most frequently seen in the male following a carcinoma of the prostate. It is commonly observed involving the bones of the thighs, pelvis and spine. Roentgenographically the point of origin is medullary. There is no production or destruction, but the bone substance is replaced by a dense calcareous material. The normal bony outline is retained.

There is no expansion. The normal cortex is thinned but present and there is no invasion. The joint surfaces are not involved.

LECTURE NO. 6

Acute Periosteitis: Considered under superficial osteomyelitis.

Chronic Periosteitis: Different varieties. Roentgenographic appearance in the simple inflammatory form. Importance of the differentiation between the simple pyogenic or luetic forms where the periosteal production is laid down parallel to the long axis of the bone, the late syphilitic periosteitis where the productive lines are at right angles to the shaft, the terminal ends uniting, giving a "lace-work" effect, and a periosteal sarcoma where the production is at right angles to the shaft with free ends to the radiating lines, producing a "sunburst" appearance.

Acute Osteomyelitis: Varieties. Endosteal or deep; periosteal or superficial. Emphasis laid on the negative roentgenographic findings in the first two weeks in acute osteomyelitis. Consideration of the causative organisms. Study of the roentgenographic and pathological changes which occur in the acute endosteal form. Importance of clinical history. Diagnosis by analysis. Point of origin medullary; early destruction followed by production. The absence of expansion in this lesion, the process spreading up and down the shaft. The thinning and destruction of the cortex with perforation at numerous points. The stripping up of the periosteum with the formation of sequestra. The perforation of the periosteum and the invasion of the soft parts with sinus formation, and lastly the central production or repair from the remaining portion of the endosteum, and the formation of the involucrum from the undamaged periosteum.

Two Forms of Superficial or Periosteal Osteomyelitis: The first usually the result of trauma causing local destruction with formation of subperiosteal abscesses, and the latter caused by secondary extension from primary infection in the soft parts. Osteomyelitis following compound fracture from projectile wounds with infection; tendency to sequestration and pseudarthrosis. Repair. Consideration of acute osteomyelitis in the flat bones with the tendency to sequestration.

Chronic Osteomyelitis (endosteal form): Most cases of the acute process become chronic from remaining traces of the infection with the repeated formation of sequestra. Brodie's abscess with its chronic history and its characteristic roentgenographic appearance of a bone cavity with sclerosed edges. The superficial form of chronic osteomyelitis with persistent sinuses and localized destruction. Rare forms, tuberculous and syphilitic. Tuberculous very chronic, liable to be multiple; occurs most often in children; other manifestations to aid in diagnosis. Syphilitic osteomyelitis, long standing lesion. Roentgenographically shows extensive changes without corresponding clinical manifestations. History and Wassermann test aid in the differentiation.

LECTURE NO. 7

Syphilis (congenital and acquired): General consideration of the productive tendency of syphilitic infection of bone. Pathological and roentgenographic changes that occur in endosteal and periosteal lesions both in the early and late manifestations, special attention being paid to the simple periosteitis syphilitica in differentiation from the late form. Description of the serrated appearance of the epiphyseal cartilage in the congenital form in children with the causes for these changes. The value of the Wassermann reaction in these lesions. Syphilis of the flat bones with differentiation roentgenographically.

Rickets: Description of the pathological and roentgenographic changes which occur in this disease, special attention being paid to the hemorrhagic changes in the epiphyseal cartilage and the softened flaring ends of the diaphysis as well as the bowing of the long bones and their tendency to fracture.

Scurvy: Study of the pathological changes that occur in the epiphyseal cartilage. The early dislocation of the epiphysis with soft part thickening and the formation of the white line at the epiphyseal cartilage; the second stage manifesting itself by subperiosteal hemorrhages; the third stage by absorption and ossification of these hematomas with the resultant bone deformities. Roentgenographic appearance in each stage.

Ossifying Hematoma (hemorrhage beneath the periosteum) is seen most frequently following trauma, also in scurvy. *Early* roentgenographic findings, except in scurvy are rather unsatisfactory. In about three weeks the periosteum begins to lay down new bone and the blood clot undergoes organization with deposition of calcium salts. The bony deposit is always in striæ parallel to the long axis of the bone; this is important in the differentiation from malignancy where the striæ are perpendicular to the shaft.

Myositis Ossificans (ossification in the muscles): History of trauma in the local cases. Roentgenographically it is seen following the lines of the muscle fibers, having no connection with the periosteum. There is a general form, constitutional in character. Etiology uncertain. The muscles progressively undergo calcareous degeneration.

Osteitis fibrosa cystica is a rare condition characterized roentgenographically by a softening of the bone, bowing with cylindrical expansion of the shaft, and formation of multiple cysts. The cortex is as a rule intact unless fractured. Seen most frequently in young adults and observed more often in the upper end of the femur than in any other of the long bones.

Osteitis Deformans (commonly known as Paget's disease): Sometimes this condition is mistaken for the resultant of osteomyelitis. It is seen in the long bones and skull. The long bones are enlarged and bowed; the normal bone markings are lost and replaced by longitudinal areas of absorption intermingled with striæ of longitudinal increased bony formation; the cortex as a rule is thickened. The condition may be local; it is almost always a general condition with accompanying changes in the skull which becomes enlarged and shows irregular thickened areas of bony deposits. As a rule there is an accompanying calcareous arterial degeneration.

LECTURE NO. 8

Arthritis: Importance of a knowledge of the roentgenographic appearance of the normal joint with a study of the soft parts, articulating cartilages, the synovial membrane and the synovial fluid. General consideration with classification:

- Arthritis
  - Acute
    - Polyarticular rheumatism
    - Traumatic Synovitis
    - Infectious
      - Pyogenic
      - Pneumococcic
      - Gonorrheal
      - Tuberculous
      - Syphilitic
      - Unknown origin
  - Chronic
    - Hypertrophic
    - Atrophic

Acute Polyarticular Rheumatism: Roentgenographic findings indefinite. Soft part swelling; increase in synovial fluid; no destruction of the cartilages. Value of the comparative study of the interarticular space. After subsidence of inflammation return of joint to normal.

Acute Traumatic Synovitis: Roentgenographic findings; swelling of the soft parts; increase of synovial fluid as shown by increase of interarticular space; no cartilaginous destruction. Importance of study of normal in comparison. Need of roentgenograms showing soft part detail. History of trauma. Tendency to recur. Resultant: Normal joint.

Pyogenic and Pneumococcic Arthritis: Roentgenographic consideration: First stage, periarticular swelling; increase in synovial fluid; no cartilaginous changes. Second stage, decrease in periarticular swelling; decrease in synovial fluid; erosion of cartilages with some destruction of bone beneath and at the same time some bony production at the edges of the articulations. The characteristic point in this form of in-

fectious arthritis is the destruction and repair going on at the same time. There is some atrophy of bone from disuse. Third stage, subsidence of the periarticular swelling; disappearance of the increase of synovial fluid; cessation of destruction; increase in production with partial or complete ankylosis, depending upon the severity of the infection and the amount of the joint involved; disappearance of atrophy.

Gonorrheal Arthritis: Roentgenographic findings depend upon the severity of the lesion. As a rule, we have the same three stages as in the pyogenic form. The process has a tendency to more extensive destruction of the articulating cartilages and the bone beneath. There is seldom any evidence of repair in the second stage and we are more liable to have firm bony ankylosis in the stage of repair.

LECTURE NO. 9

Tuberculous Arthritis: In adults the primary focus is usually in the epiphysis with extension into the joint. In children we see a distinct synovial form. Roentgenographically in the first stage we have extensive periarticular swelling, often before the bony defect is detected; this gives us the characteristic fuzzy appearance of the roentgenogram. Importance of comparative studies of the normal. There is an early tendency to bony atrophy. The synovial fluid is increased. The different stages are lengthy when compared with the pyogenic and gonorrheal form of arthritis. The second stage is characterized by destruction of the articulating cartilages and the bone beneath; this destruction may cover a period of years; the synovial membrane may be destroyed with invasion of the soft parts surrounding the joint and formation of sinuses; when this has occurred there is liability to a mixed infection, which is shown by bony production. When we have a straight tuberculous infection without sinus infection, production does not occur until the late third stage when we see subsidence of the inflammation with the formation of fibrous or bony ankylosis, partial or complete. The complete sequence of events may cover a period of years.

Syphilitic Arthritis: The simple form shows extensive periarticular swelling, fuzziness to the roentgenogram from thickening of the synovial membrane, and increase in the synovial fluid; no cartilaginous destruction or subsidence or inflammation. The joint is restored to normal. History and Wassermann test aids in diagnosis. Serration of the epiphyseal cartilage often accompanies these joint changes; more frequently some periosteitis is detected at the junction of the epiphyseal cartilage and the end of the diaphysis. Often a "punched out" appearance at this point is observed; when detected it is sufficient for diagnosis.

Charcot Joint (neuropathic): Not infectious. Indirectly due to syphilis. Characterized roentgenographically by great increase in size of joint; increase in synovial fluid; destruction of the articulating cartilages; eburnation of the ends of bones and formation of varying amount of detritus within the joint. There is no bony atrophy. The clinical picture of a loose, wabbling painless joint, with considerable function, is an aid in diagnosis.

Infectious Arthritis due to Unknown Causes: Usually presents the roentgenographic picture of a pyogenic arthritis.

Hemophilia may occur in a joint giving changes similar to tuberculosis. The clinical history will aid in clearing the diagnosis.

LECTURE NO. 10

Atrophic Arthritis: Disease of middle age. There is marked atrophy of the soft parts and the bones; partial subluxation may occur; there is destruction of the cartilages with *no* production. There is no increase in the synovial fluid.

Hypertrophic Arthritis: Common joint disease of middle and old age. Roentgenographically there is no atrophy, rather an increase in the bone density. Articulating cartilages are thinned or destroyed with productive lipping at the edges. This production may form knot-like bony formations which may break off and lie loose

in the joint, commonly known as "joint mice." In the late stage we may have flattening of the articulating ends of the bone with some eburnation. The production may be so extensive as to bridge from one bone to the other causing ankylosis. Trauma may "light up" an old hypertrophic arthritis with marked increase in the loss of function.

REMARKS

All of the lectures were fully illustrated by lantern slides showing typical lesions. In addition all students in sections were given as near as possible individual instruction for two weeks in the interpretation of roentgenograms showing the subjects lectured upon. They were required to examine and report fully on each case. Instructors then went over the interpretation with each student, correcting the errors as shown by the report, and upon this daily showing, combined with the results of a weekly examination, the student was rated.

TYPICAL EXAMINATION

1. What are the advantages and disadvantages of fluoroscopic examination in bone lesions?
2. What are the advantages and disadvantages of the plate method of examination in bone lesions?
3. Describe the technique used in the correct roentgenographic examination of the occipital region.
4. What are common injuries to the ankle joint? What is the important factor in these injuries?
5. What are the most common injuries to the carpals? Describe fractures.
6. What is the capitellum? Name the common injuries to the elbow.
7. What is the cardinal rule to follow in the examination of skull and spine cases? Describe the proper method for the lateral examination of the cervical spine.
8. How would you detect a fracture of the neck of femur and how would you ascertain whether impaction is present?
9. Why is the prognosis in fractures of the middle third of humerus especially bad?

SYNOPSIS OF LECTURES ON THE CHEST

Lecturer: Lieut. Col. W. F. Manges, M.C.

LECTURE NO. 1

Brief review of anatomy and technique of examination.

Types of chests, usually true to general physique of patient. (Illustration of extremes, and mean, including consideration of all thoracic contents and diaphragm.)

Trachea, position, bifurcation, displacement important sign. Main bronchi and their divisions into trunks, distribution. Subdivisions seen only in plates of sharp detail, and then not to the surface of the lung in the normal.

Location of fissures, deviations from the normal, supernumerary or partial lobes not uncommon.

Hilum area, normal a matter of judgment, and based on observation of many apparently healthy individuals. Calcified or otherwise dense glands found as result of dust collections, previous acute infectious diseases, or tuberculous infection in childhood. Contributive evidence only.

Technique of Examination: Fluoroscopic and plate methods, advantages of each.

LECTURE NO. 2

Pulmonary Tuberculosis

Peribronchial: Localized peribronchial thickening, never general or widespread. Most frequent in distribution of vertebral and first interspace trunks. Exudate not marked as a rule when cases are seen, but may be sufficient to obscure detail of tubercle shadows. Small tubercle shadows give bronchi beaded appearance, and bronchial divisions may be traced from the hilum to the surface. Tubercles usually small. Tends to progress into parenchymal

type, but may heal without involving parenchyma. Patients seldom sent for examination, or roentgenologists do not recognize it. Diagnosis difficult, following acute bronchitis, bronchopneumonia, or influenza. Differential diagnosis depends on location, persistence of thickening, and beaded appearance of bronchi.

Parenchymal Tuberculosis: May be extension from peribronchial type, or apparently start in parenchyma. First appears in upper lobes, usually above or in second interspace. In exudative stage shadows of more or less distinctly localized consolidations appear. They may be filmy in character and are near the surface as a rule. Patients not sent for *x*-ray examination as a rule in this stage. Following exudative stage, lesions become more sharply circumscribed, due to formation of fibrous tissue; and shadows of organized tubercles, conglomerate, caseous, or calcareous, appear. The linear markings become more distinct and straighten out, extending from periphery to hilum. In short, the lesion passes from acute to chronic fibroid or fibrocaseous. May remain localized and heal, becoming chronic inactive, or heal at one place and progress downward in another, becoming chronic active tuberculosis, in which case it always becomes bilateral and again starts in the upper portions of the lobes of the other lung and progresses from above downward.

Involvement of costophrenic area of lung is rare, even in advanced cases, though pleural involvement is common in this region. Abscesses or bronchiectatic cavities, common in upper chest, uncommon in lower lobes. On re-examination at intervals nodular shadows and linear fibrosis more sharp in outline, but do not disappear. Patient may be acutely ill with small area of lesion, or on the other hand may have extensive involvement with comparatively slight clinical manifestations. The roentgenogram is no indication as to virulence of lesion, and frequently fails to determine question of activity, except by repeated examination.

Acute miliary tuberculosis, seldom seen in *x*-ray laboratory, entire lung area dense, contrasty plates impossible, tubercles give lung granular appearance.

LECTURE NO. 3

Bronchitis and Bronchopneumonia.— As a result of repeated attacks of bronchitis root and bronchial shadows become exaggerated. They are not nodular and do not tend to straighten out. Differentiated from infiltrating process of syphilis only by other tests, or in presence of other contributory evidence such as history of primary lesion, dilatation of aorta, etc. Condition common also in asthmatics. General peribronchial thickening is seen after long exposure to dust.

The findings in bronchopneumonia depend upon time of examination. When patients are seen early in course, and rayed repeatedly, areas of consolidation appear from time to time and progress from root to surface, most frequent in lower lobes or mid-portion of lung; one area may be receding while another progresses. Consolidations may be small or large, abscess or interlobar empyema may occur but not as common as in lobar pneumonia. Root and trunk shadows remain heavy for weeks or months, but usually resume normal appearance in uncomplicated cases. Lesion may be more or less nodular and when involving upper lobes may be mistaken for tuberculosis, but these nodules disappear gradually. Condition has not been studied extensively by *x*-ray, except in late stages, or in delayed convalescence. Single plates at bedside usually satisfactory for study of progress. Consolidations may or may not reach surface of lung, and can be detected on plates sometimes days before physical signs appear. Differential diagnosis depends upon more or less rapid change of shadows from day to day, and variety of location, as well as size of consolidations. Prognosis unfavorable when consolidations are numerous, large, and slow to disappear.

LECTURE NO. 4

Lobar Pneumonia: Involvement of one or more lobes, more frequent in lower lobes. In early stage general increase in density, no heavy detail seen. Consolidation rapid, and when complete nearly all detail obscured and remains so until resolution takes place. Consolidation does not progress from hilum to surface, is same throughout lobe. Diaphragm shadow indistinct when lower lobes are involved, but not completely obliterated in uncomplicated cases.

In absence of complications, lobe density disappears rapidly after crisis, but heavy detail remains and leaves only gradually. Certain amount of fibrosis is apt to take place. Complications of pleura, such as effusion, empyema, or adhesions are common, and these together with delayed resolution or abscess formations, which are not infrequent, furnish the usual excuse for roentgenographic study. Conditions of pleura are treated further on. Abscess formation may be mistaken for central consolidation or even interlobar empyema. Repeated examination shows gradual sharpening of outline as abscess wall becomes more organized; tends to discharge through bronchus; and as the center undergoes liquefaction and the cavities contain more or less air, fluid levels can be seen if patients are rayed either in the upright position or while lying on unaffected side. Cavities may be large, small, single, or multiple, more common in lower half of chest. Inflammatory thickening of abscess wall gradually disappears and only slight fibrosis may remain. Dilatation of bronchi occurs occasionally.

Delayed resolution is recognized by prolongation of lobe density, and heavy peribronchial shadows. When an upper lobe only is involved condition is difficult to differentiate from tuberculosis except by repeated examinations. General density and peribronchial shadows disappear gradually, whereas they do not in tuberculosis, and any interstitial thickening that may remain after pneumonia does not have the nodular appearance seen in tuberculosis. Pneumonia in any stage or complication involving only the lower lobes is never looked upon as being tuberculosis. Almost daily bedside examination is practical and should be of value.

Cavities (Abscess and Bronchiectatic): Abscess cavities in tuberculosis are common in upper lobes, not large as a rule, single or multiple, resulting from breaking down of large conglomerate tubercles, and discharging through bronchi. They become infected with pyogenic organisms as well. Abscess walls may be thick or thin, depending on amount of fibrosis, but usually irregular.

Early, wall not sharply outlined nor of definite shape, inner surface not smooth, but becomes more so with age, and finally cannot be differentiated from bronchiectatic cavity. Seldom seen to contain more than small amount of pus. Uncommon in lower lobes.

The abscess due to pyogenic organisms following or complicating pneumonia is more apt to be single, may occur in any portion of lung but more frequent in lower lobes. Walls are usually thick, dense, and more or less irregular in outline. Pus level demonstrable, as a rule, unless inflammatory areola closes in and obliterates cavity. Ulceration into bronchus may provide free drainage, in which case healing is rather rapid as a rule, and fairly complete, so that evidence of cavity may disappear. It is very difficult to differentiate from localized interlobar empyema. Fluid level is best point, aside from location. Remaining fibrosis does not resemble that of tuberculosis. Diagnosis should not be concluded on single examination unless fluid level is demonstrated. Fluoroscopic examination very valuable. Abscesses following inhalation of foreign bodies, single or multiple, tend to increase unless foreign body is removed; fluid level seldom seen. Persistent abscess in lower lobes always suggestion of foreign body.

Bronchiectasis is recognizable in two

forms: 1. The more or less cylindrical-shaped dilatation of the larger bronchi. 2. More or less spherical-shaped dilation of smaller bronchi. First type easily overlooked and require plates of fine detail; recognized by shadows of bronchial walls. May involve only one or multiple bronchi. Not apt to be more than two or three times diameter of normal bronchi. Second type, characterized by thin wall, although surrounding fibrosis may be excessive, smooth lining, variation in size from very small to very large, holding as much as a pint at times; variation in number from single to large numbers. Caused by contraction of tissue undergoing fibrosis, or possibly by excessive strain of cough. They do not tend to decrease in size, and in the lower lobes usually contain considerable exudate. Clinical symptoms and signs very important, frequently positive, and should complete differential diagnosis.

LECTURE NO. 5

Tumors of the Lungs. Cysts, usually single, apt to be large, round, very dense, and smooth surface.

Benign Tumors, rare except glandular enlargement in root area or mediastinum, e.g., Hodgkin's disease, substernal thyroid. Position, size, shape, and clinical findings complete diagnosis.

Syphilis of the Lung may appear as mass (gumma) usually at mediastinal border, of variable size and more or less irregular outline. Or as diffuse infiltration along bronchi. In latter type infiltration involves most bronchi, but does not extend to surface. Either type apt to be associated with dilatation of aorta. Positive history or Wassermann test may be necessary to complete diagnosis, as the condition resembles carcinoma, or interstitial changes from other causes. Re-examination after appropriate treatment shows diminution of shadows.

Carcinoma of the Lungs: Primary type rare, infiltrating in character. Metastatic, common, two types, infiltrating and miliary. Infiltrating type may present mass in hilus with peribronchial infiltration or distinct mass may be absent. Pleural involvement with effusion is common in this type. History of primary growth secures diagnosis. Miliary type is characterized by multiple nodules widely distributed, usually small, rather sharply outlined and quite dense, but not really smooth-surfaced.

Sarcoma is only metastatic in the lungs. Sarcoma of chest wall may project into lung area, and is differentiated from encysted empyema by evidence of destruction in portions of one or more ribs. Metastatic lesions usually multiple, vary in size from smallest recognizable to masses of great size, relatively lacking in density, are encapsulated, therefore very smooth on surface and round. History of primary lesions not necessary for diagnosis, appearance on plates is characteristic.

LECTURE NO. 6

Lesions of the Pleura. Serofibrinous: Acute pleuritis with or without pneumonia. No signs on screen or plate until fluid or fibrin appear. Fluid or fibrin or both present in varying quantity. First seen at costophrenic angle, no sharp level present. Upper border oblique from above, downward, and inward, and changes slightly with posture of patient. Visceral and parietal pleura not thickened materially or adherent early, but organization may take place in fibrin as well as adhesions form between parietal and visceral layers, when effusion becomes encysted, but apt to become purulent by time this stage is reached. Sharp outline of fluid strongly indicates empyema. Diaphragm shadow is obliterated when exudate is present in quantity. Only general estimate of quantity can be made. Consolidated lower lobe with small amount of fluid difficult to differentiate from larger amount of fluid alone; only reliable sign is displacement of heart, which is always present with large amount of fluid, and much less so with consolidation of lung and but little fluid. Consolidation of lung alone does not completely obliterate diaphragm shadow. Re-

peated observations determine increase or decrease of fluid.

Adhesive Pleuritis presents signs on the screen or roentgenogram when pleura becomes definitely thickened or adhesions to diaphragm occur. Associated with but little exudate, may be end result of serofibrinous type. Costophrenic angle frequently obliterated.

Purulent Pleuritis is usually a complication or sequel of pneumonia, or penetrating wound. One-half of chest cavity may be completely filled with pus, but lesion is usually more or less encapsulated by adhesions (encysted or encapsulated empyema). May be found in any location where two pleural surfaces are in contact. Axillary border common location, also interlobar area. More frequent along mediastinal border than is ordinarily considered the case. May develop from serofibrinous type or in hemathorax, but most frequently pyogenic from the start. Shadows are very dense, sharply outlined in encysted type. Pleura becomes greatly thickened. Interlobar or mediastinal type may discharge by rupturing into bronchus. Empyema in contact with chest wall demands drainage, and site of this is best determined by the stereoscopic plates as well as viewing from all angles by means of fluorescent screen. Pleura tends to become greatly thickened and then cavity remains after drainage. In chronic empyema after drainage, roentgenograms of good quality reveal thickness of pleura, extent of drainage, and size of cavity. Cavities or sinuses are studied to advantage after injection of bismuth subcarbonate or oxychloride in sterile olive oil. Heavy pastes should not be used. Surgical procedure is based almost entirely on roentgenographic findings. Patients should be rayed in different positions and especially stereoscopically when injected. Bronchial fistula is not uncommon, readily diagnosed by means of injection.

LECTURE NO. 7
Pneumothorax

Spontaneous type due to tear in visceral pleura through traction on adhesion, or by ulceration, may be partial or complete. Border of lung usually seen on plate, also adhesions holding parts of lung to chest wall. Diagnosis depends on absence of lung detail, or detail of compressed lung, and displacement of the heart and mediastinal structures. Prognosis is good in uncomplicated cases. Tuberculous foci frequently found in opposite lung. Condition may be complicated by hemorrhage and become hemopneumothorax, or by infection and become pyopneumothorax. Serous effusion may also occur. When cavity contains fluid of any kind, a sharp fluid level can be seen, and this changes with change of posture of patient. Percussion of the chest wall causes wave motion which is clearly seen on fluorescent screen. Occasionally the character of fluid may be determined by character of the waves. Repeated examination reveals progress of the condition. Penetrating wounds of chest frequent cause, *x*-ray findings same as above described, and in addition fractured rib or foreign body may be seen on the plates.

LECTURE NO. 8
Heart and Aorta

Heart.—Fluoroscopic study important because of constant motion of heart. Character of pulsation at times is more important than size of heart. Bedside fluoroscopy is practicable, especially when pericardial effusion is to be differentiated.

Plate study is of value, especially when there is a focus point—plate distance of six feet. A carefully centered single exposure usually affords about as much information as stereoscopic plates.

The size, shape and position of the normal heart shadow vary with the size, shape and type of individual; e.g., the heart of the robust, deep-chested, hard-muscled man is found to be more or less transverse, for the reason that the diaphragm is high, whereas in the slender, flabby individual, with ptosis of abdominal organs, the heart is more nearly vertical, and therefore presents a smaller transverse diameter. In this

respect, one finds wide variation in the normal. When doubt exists as to whether the heart is of normal size, recourse should be had to one of the heart measurement tables (see U. S. Army *X*-Ray Manual). The right border presents two curves in the normal, that of the right ventricle and the right auricular appendage, and the vena cava, or at times the ascending aorta. The left side presents three curves, the aortic arch, the left auricle, and the ventricle; occasionally a fourth is seen, the pulmonary artery.

Enlargement of heart shadow is due either to hypertrophy, dilatation or effusion in the pericardium. It is displaced by pressure, as in the case of total empyema or pneumothorax, or by traction, as in adhesive plueropericarditis, or contraction of one lung. Occasionally one sees the heart reversed as to sides—transposition, and abdominal organs are also transposed.

Enlargement of hypertrophy is due to excessive physical exertion, to valvular lesions, or obstruction in other parts of circulatory organs, e.g., chronic interstitial nephritis. On fluoroscopic examination, such a heart will show deep, strong, but not as a rule a very rapid pulsation. The aorta, too, will show relative increase in size, except in aortic stenosis or mitral regurgitation.

The transverse diameter becomes more nearly horizontal, and the angles or curves are more acute. Lesions of the mitral valve are accompanied by relative increase in size of left auricle. Breathing is apt to be normal.

Dilatation, either following or occurring independently of hypertrophy, gives the heart shadow more the shape of a pear; the aortic shadow may be normal, and pulsations are feeble, fluttering, shallow, irregular, and usually rapid. Pulsations may be relatively more noticeable in auricular outline than in ventricular. Breathing is apt to be shallow and rapid. Lungs have much the appearance of general peribronchial thickening. This is due to engorgement of blood vessels, and is usually more noticeable in the right lung.

Pericarditis with effusion may give much the same shaped shadow as dilatation, especially when fluid is relatively small in quantity. When pericardial sac becomes distended, the shadow becomes more nearly round, and less nearly pear-shaped. Fluoroscope gives best results, as pulsations become faint and wave-like.

In chronic adhesive pericarditis, heart is displaced; diaphragm fixed to pericardium causes limited motion in diaphragm.

Aorta: Change in size and shape of thoracic aorta may be due to general dilatation and elongation, sometimes called tortuous aorta. Common in late life. Or change may be due to localized dilatation and is then known as aneurysm. Any part may be the site of lesion, or the entire thoracic aorta may be involved. First portion of descending arch is most frequent site. Aneurysms usually project laterally, but occasionally only posteriorly, when lateral or oblique view is necessary to demonstrate their presence. Fluoroscope necessary to differentiate from mediastinal tumor at times, and is a study of pulsation. Plates of fine quality, especially in detail, will occasionally show shadow of atheromatous deposit in wall of aneurysm.

These lectures on the chest were illustrated by carefully selected lantern slides, demonstrating all the points to which attention was called.

SYNPOSIS OF LECTURES ON SINUSES, MASTOIDS, AND TEETH

Lecturer: Lieut. Col. W. F. Manges, M.C.

Sinuses: The first lecture was devoted to demonstration and discussion of the wide anatomical variations, and the technique of exposure, with special reference to care necessary to avoid damage by overexposure or repeated exposure.

The second lecture dealt with lesions of the frontal sinuses, and ethmoid cells. In the third lecture, the lesions of the sphe-

noid sinuses and maxillary antra were considered, as well as combinations of involvement.

The fourth dealt with anatomy and types of mastoids and the technique of examination.

The fifth lecture was on the pathology and complications of mastoids. Special attention was paid to the relation between the lateral sinus and the auditory meatus, and also the postoperative examination, to determine whether any cells remained undrained.

In the sixth lecture, the anatomy and physiology of the teeth and adjacent structures, also the technique of exposure and adjustment of film as well as plate examinations, were considered.

The seventh lecture covered dental and jaw-bone pathology.

There was at all times an abundance of clinical material, both sinuses and mastoids as well as teeth, so that in addition to the lectures and lantern slide demonstrations, the student officers received further practical instruction in the radiographic and interpretation rooms on the subjects.

An additional lecture on brain tumors was given to each class as nearly as possible. This subject was not looked upon as being important from a military point of view, but our collection of lantern slides illustrating many proven cases of various types of tumors afforded most valuable and interesting material for the general subject of interpretation.

LECTURES ON URINARY AND GASTROINTESTINAL TRACTS

The lectures on the urinary tract and the gastrointestinal tract were given by Capt. Myron B. Palmer until he was called to the Surgeon General's Office for duty, and then by Capt. E. S. Blaine. These subjects were approached from a very practical view-point, and only the more common organic lesions were shown. It was, however, considered wise to teach the technique of examination fairly thoroughly with the idea in mind that there would be work of this kind to do in base hospitals, and during the reconstruction period. Then, too, we encouraged the hospital staff to send such patients to us, for they added to our radiographic and fluoroscopic material.

SYNOPSIS OF LECTURES

GIVEN BY LIEUT. CHARLES A. WATERS, M. C., U. S. A.*

LECTURE NO. 1

The Roentgenological Situation in the American Army at the Beginning of the War

Organization of the earliest separate schools for instruction in roentgenology.

First expedition to France, June, 1917.

Tours of inspection to British and French hospitals, including the base and advanced hospitals, especially the mobile formations near the front.

Lessons learned: That surgery must be done in as short a time as possible following the injury, three to five hours. That wherever surgery is done, *x*-ray work is done also. That a small portable type of *x*-ray apparatus capable of generating its own power is necessary. The character of *x*-ray work done in the different types of hospitals, mobile, evacuation and base hospitals. The large number of roentgenologists necessary to care for the sick and wounded. That trained enlisted personnel familiar with the care and handling of *x*-ray apparatus and capable of doing photography is necessary.

LECTURE NO. 2.

The X-Ray Department and the Roentgenologist

Current conditions; Supplies; Difficulties met with in the localization of foreign bodies.

Relationship between the *x*-ray department and the other departments of the hospital. Personal conferences between roentgenologist and the chief surgeon and

* This series of Lectures has not been published.

his staff, organization of department. Roentgenology is a subdivision of surgery. That we wish, above all things, to help and assist the other departments of the hospital in effecting the most efficient methods in the diagnosis and treatment of war conditions.

Cooperation at all times of the day or night in a spirit which will win admiration for the roentgenologist and his staff. Things which attract attention: Politeness and assistance by the enlisted personnel in the department towards the other departments in the hospital. Turning out always the best quality of work. Keeping in very close and intimate touch with everything pertaining to the *x*-ray department. Establishing a precedent that you are there to serve and not to dictate.

Arrival of wounded soldier. Under bad, disagreeable conditions, cold winter nights. Get fire started immediately so that patient will have a warm *x*-ray room to be examined in. Kindness and consideration shown the wounded soldier is greatly appreciated. Have cigarettes handy for them. Fear of a big surgical operation and anesthetic staring them in the face.

LECTURE NO. 3

The Roentgenologist Overseas

Arrival of roentgenologists attached to organized Units; opportunity for observation work with older Units.

Arrival of casual roentgenologist; assignment to staff of Senior Consultant in Roentgenology, A. E. F.; periods of instruction in localization of foreign bodies; reassignment to units at the front or rear.

Esprit de Corps; a great honor to work up front. If you fail to make good at the front you are sent to a unit in the S. O. S. (Service of Supply).

Hospitals in France; base hospitals, advance base hospital 30–50 miles behind the lines. Base hospital areas which relieve the advance base hospital. Rear base hospitals. Ports of debarkation.

Evacuation hospital 5–10 miles behind the lines.

Field Hospitals, Divisional Units. *X*-ray and surgical personnel and apparatus, supplied by headquarters, medical and surgical consultants, A. E. F.; what happens to the apparatus and personnel of a Field hospital when a division goes into repose.

Mobile Hospitals; power, *x*-ray and sterilizer supplied by motor camions; mobile surgical units; units belonging to the headquarters of medical or surgical consultants.

The Triage or Receiving Ward; wounded arrive on stretchers mostly; cloth is cut away; valuables are checked; head and pubic hairs are shaved; patient is deloused; is given bath, a bath-robe and pajamas; then is sent to the preoperative ward.

The Preoperative Ward; old dressings put on in regimental dressing station are replaced with fresh, small, sterile ones; record and description of the wound or wounds are made; shock beds; transportation to the *x*-ray room.

LECTURE NO. 4

Systematic Methods of Examination. Records

Importance of the *x*-ray department to care for the work during rush periods. Preparation of the *x*-ray department during quiet times to meet conditions during the pushes; dividing the staff and enlisted personnel into teams; dividing the working time into eight-hour periods; amount of work one *x*-ray team is capable of doing in eight hours; records; importance of following a routine form for the description of the *x*-ray findings; time saving; importance; cite example.

Methods employed in the localization of foreign bodies; the nearest point; the triangulation method of Strohl; the parallax; the Hirtz compass; Intermittent control.

A brief description of the vital points in the proper execution of these methods.

Skin marking. Difficulties to overcome (pus, blood, dirt, washing with soap, water, alcohol, ether, iodine). Different materials employed; good and bad points of each; Finzi ink; pyrogallic acid and silver nitrate; indelible pencil; skin pencils; small knife

cuts; tattooing. Advantages and disadvantages of each.

LECTURE NO. 5

The *x*-ray examination of the more uncommon war injuries and diseases; especially those of the head, thorax, abdomen, pelvis and larynx.

Compound fractures and fractures into the joints caused by through and through wounds.

Importance of rotating the patient from side to side in determining whether a foreign body is within a closed cavity or not.

Importance of giving to the surgeon all anatomical landmarks in close relationship to the foreign body.

The diaphragm: Its rôle in foreign bodies which have entered the lung, pleura or abdomen.

Dangers associated with the extraction of foreign bodies from the larynx and neck with the aid of the intermittent control.

The Belot method of fluoroscopic localization of foreign bodies in the eye.

THE MANIPULATOR'S SCHOOL

MACHINE COURSE

Instructor, Lieut. E. H. Herzer, S. C.; *Assistant Instructors*, 2d Lieut. L. S. Uphoff, S. C., 2d Lieut, W. W. Mowry, S. C.

The instruction to manipulators was limited to the theory, operation, maintenance, and repair of the various types of apparatus. During the last few months only a small percentage of enlisted men were brought in contact with the large so-called "Base Hospital" machines. These were the men who, by reason of previous experience or education, were especially fitted for such instruction. Their course in the handling and caring for the portable types and induction coil outfits and especially in the Delco engine was very thorough.

MANIPULATOR'S SCHOOL
SCHEDULE

	Machine Course, Electricity and Coil Units		Machine Course, Portable Units		Developing and Dark Room		Position and Exposure Drill	
	8:00–11:30 A.M.	1:00–4:30 P.M.	8:00–11:30 A.M.	1:00–4:30 P.M.	8:00–11:30 A.M.	1:00–4:30 P.M.	8:00–11:30 A.M.	1:00–4:30 P.M.
1st week.....	A	B			B	A		
2nd week.....	B	A			A	B		
3rd week.....			A	B			B	A
4th week.....			B	A			A	B
Sec. A—24 men. Sec. B—24 men.								

Their instruction in position and exposure drill was limited, and given in such a way that it served more to fasten in their minds the knowledge they had gained in the machine and developing work than to make real operators of them. Anatomical terms, other than those familiar to any schoolboy, were not used, and only the more common positions were practiced.

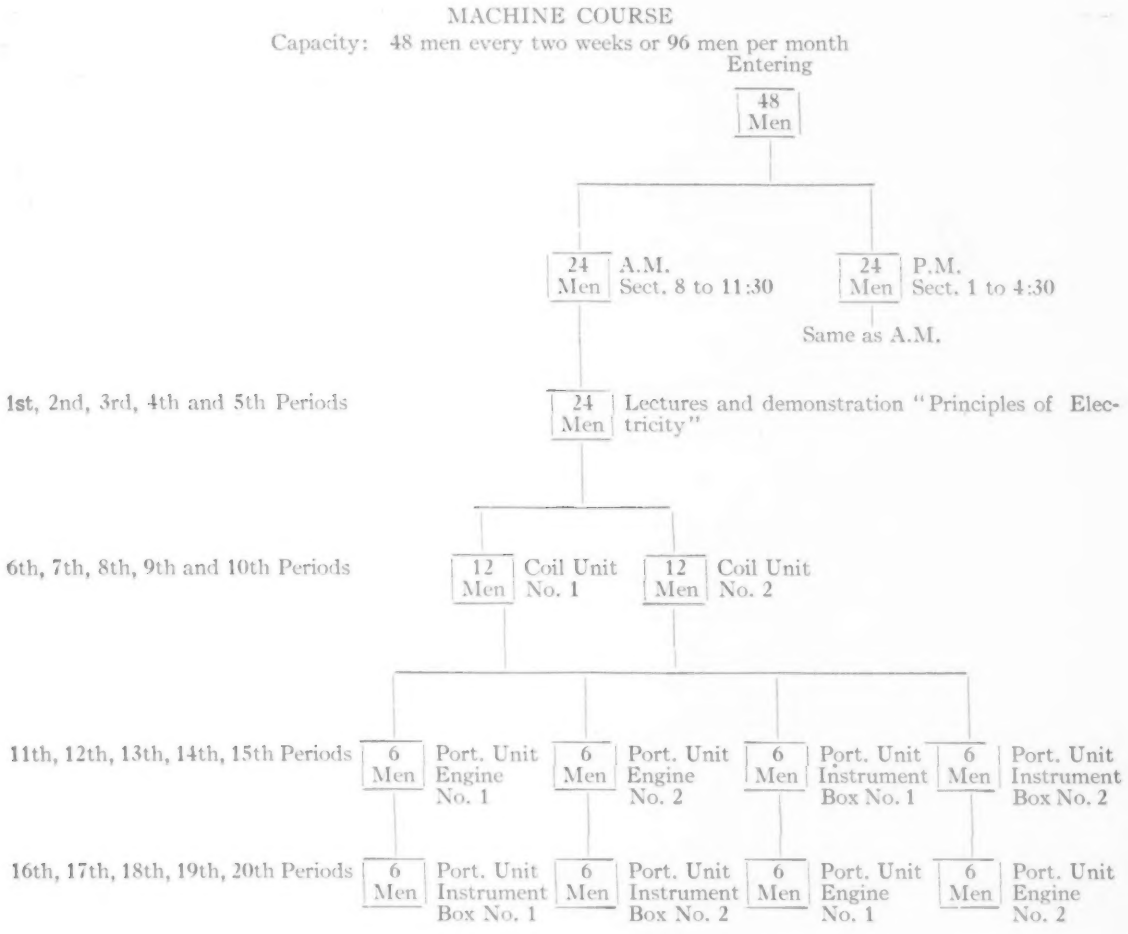
In every respect it was our aim to make their course as practical and mechanical as possible.

The instructors in the Manipulator's School were Sanitary Corps officers or graduates of former classes. We were constantly increasing the teaching facilities as well as enlarging the entire school, so that there was a constant demand for prac-

tical work in the way of wiring, both low and high tension; assembling and adjusting apparatus, and installing the various machines. The manipulators under the direction of their instructors made all the changes in building "T," even to building the developing counters and to mounting the extra large step-down transformer.

In short, it was our purpose to train them to be useful and practical assistants to medical officers, and keep them just as far from actual professional duties as possible.

The assignments of these men in the developing course were similar to those of the officers. Their hours in the machine course were so arranged as not to conflict with the officers.


MACHINE COURSE
Capacity: 48 men every two weeks or 96 men per month
Entering
48 Men
24 Men A.M. Sect. 8 to 11:30
24 Men P.M. Sect. 1 to 4:30
Same as A.M.
1st, 2nd, 3rd, 4th and 5th Periods
24 Men Lectures and demonstration "Principles of Electricity"
6th, 7th, 8th, 9th and 10th Periods
12 Men Coil Unit No. 1
12 Men Coil Unit No. 2
11th, 12th, 13th, 14th, 15th Periods
6 Men Port. Unit Engine No. 1
6 Men Port. Unit Engine No. 2
6 Men Port. Unit Instrument Box No. 1
6 Men Port. Unit Instrument Box No. 2
16th, 17th, 18th, 19th, 20th Periods
6 Men Port. Unit Instrument Box No. 1
6 Men Port. Unit Instrument Box No. 2
6 Men Port. Unit Engine No. 1
6 Men Port. Unit Engine No. 2

In conclusion, we would like to make it clearly understood that the lecture notes as published here are not to be looked upon as original articles. In the main, they follow the teachings of the U. S. Army X-Ray Manual, but they also represent substantially the outline of instruction given prior to the publication of the second edition of the Manual. The teaching material, such as plates, lantern slides, charts, etc., were collected from various sources, but for the most part came from the laboratories of the individual instructors, or were prepared at the school.

MOBILE ROENTGEN RAY APPARATUS*

BY COL. ARTHUR C. CHRISTIE, M. C., U. S. A.

WASHINGTON, D.C.

THE necessity for the employment of mobile roentgen ray apparatus in time of war has been recognized from the earliest days of the roentgen ray. Small transportable outfits were probably first used on an extensive scale during the Boer War. At that early time the outfits were necessarily very limited in their output, since even stationary apparatus was not highly developed. In all important wars since that time roentgen ray work has been done with mobile apparatus supplying its own current. The most usual type has been a coil and interrupter actuated by current from storage batteries, or from a dynamo run by a gas engine. Sometimes a small gas electric set was carried to recharge the storage batteries, and sometimes a dynamo was operated directly from the motor of the automobile in which the outfit was transported.

The World War was of such magnitude, both in respect to the total number of casualties and to the number occurring over short spaces of time in individual engagements, as greatly to increase the necessity for mobile roentgen ray apparatus. Such apparatus has been used by the French, English and Italian armies not only in order to give roentgen ray service to temporary hospitals where no current is available, but to furnish one or more additional roentgen ray plants to forward hospitals during times of great stress.

Both the French and English have depended entirely upon coil and interrupter to furnish the high tension current. The interrupter is usually of the gas-mercury type. Valve tubes are invariably used, and the roentgen ray tubes are the ordinary gas tubes. The use of Coolidge tubes is still quite limited in Europe, and so far as I have been able to learn they have never been used there with portable apparatus, except that furnished by our own Medical Department.

The primary current supply for this apparatus has been furnished in one of two ways: either from a gas-electric set, with or without storage batteries, or from a dynamo operated by the engine of the automobile in which the apparatus is transported. Fig. 1 shows the official

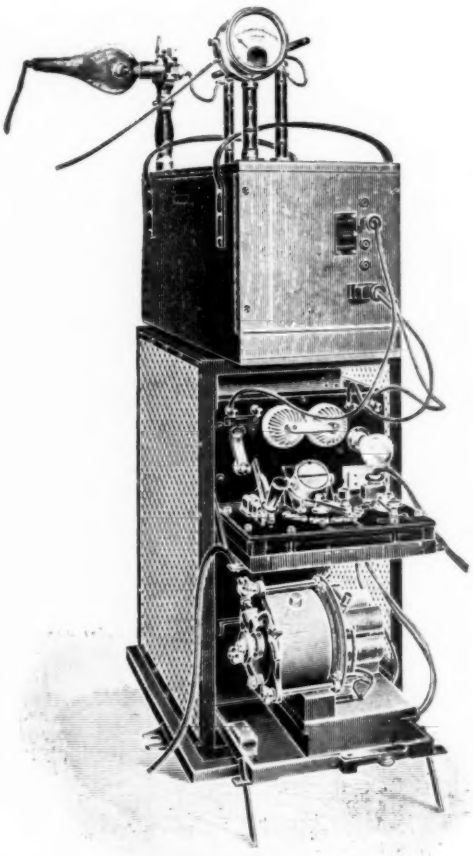


FIG. 1. ENGLISH PORTABLE APPARATUS OF 1915. COIL, INTERRUPTER AND CONTROL TABLE ASSEMBLED.

English type of portable apparatus of 1915 which receives its current supply from the gas-electric set shown in Fig. 2. This is a water cooled gas engine with direct connected dynamo delivering a current of 10 amperes at 60 volts when run at its normal speed. Storage batteries are a part of the apparatus, and by connecting them in

* Authority to publish granted by the Board of Publication, Surgeon General's Office, Washington, D. C.

series with the dynamo a current of 10 amperes at 100 volts may be obtained. This combination makes it possible to obtain 4 or 5 milliamperes through a tube of medium hardness.

Fig. 3 shows the latest type of English apparatus set up ready for operation. The canopy extension connected to the automobile serves as a fluoroscopic room. The

Equipage Radiologique with the mercury interrupter on a shelf by the driver's seat and a gas-electric generating set mounted behind the driver's seat. The latest type of French roentgen ray automobile outfit has been described as follows by Lt. Col. P. M. Hickey:

"It consists essentially of an ordinary automobile with a large box body, which

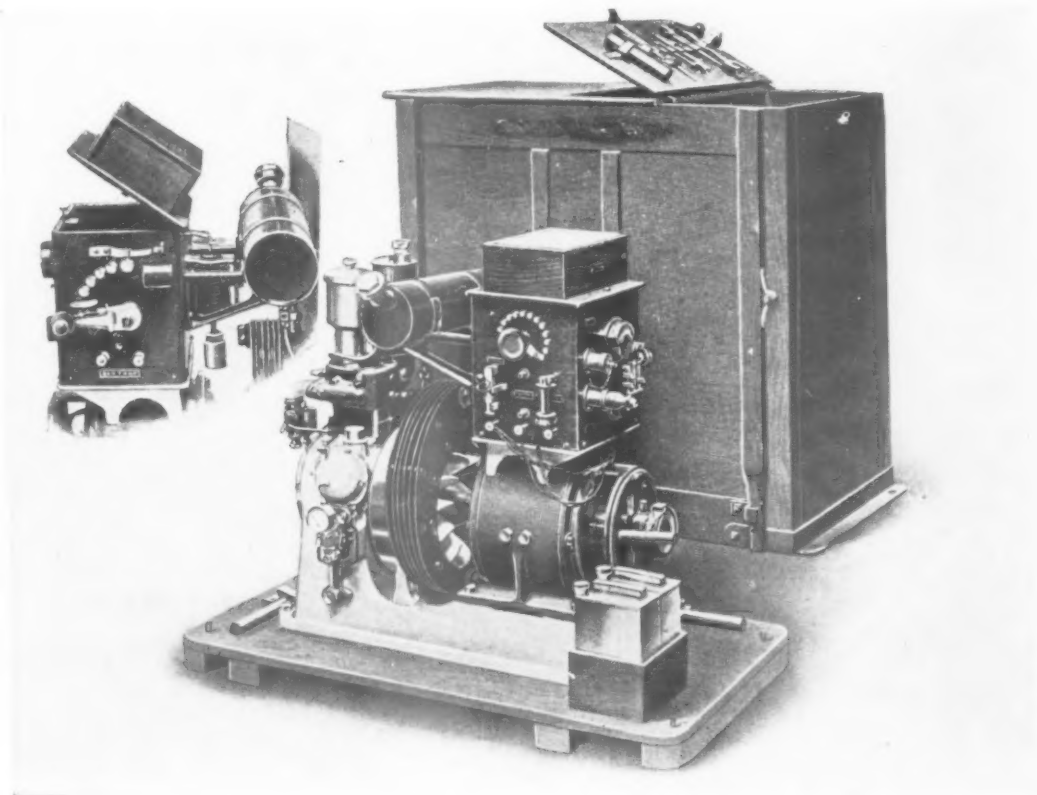


FIG. 2. GAS ELECTRIC SET OF ENGLISH PORTABLE APPARATUS.

body is thoroughly equipped as a dark room. The power for the roentgen ray apparatus and electric lights is supplied by dynamo operated by the motor of the truck.

The French service has also depended upon the coil and interrupter actuating a gas tube, and for generating apparatus has used a dynamo driven by the automobile engine, or in some cases a separate gas-electric set. The output of such apparatus is about 10 milliamperes through a medium tube. Fig. 4 represents the French

is equipped to serve as a dark room and for storage of tables, etc. The essentially new part of the outfit (Fig. 5) is that the chassis in its forward part is of a peculiar construction. Instead of terminating directly under the forward part of the hood, the front end of the chassis is elongated with a U-like projection of very heavy material. This U-shaped projection serves for the mounting of the dynamo. This dynamo is mounted on a prolongation of the axis of the crank shaft of the motor.

The dynamo is rated at 4½ K.W. There is a second low hood which covers the dynamo without disturbing the hood which covers the engine proper. The engine is a 4 cylinder machine rated at 25 H.P. The dynamo is designed to furnish current for lighting the mobile hospital unit and also to operate the roentgen ray apparatus. The interior of the body is quite spacious, the forward part being devoted to dark room equipment. On the left side are racks for drying, in the center is a commodious sink, and on the right a large washing box. On either side of the rear entrance are large well fitting cupboards with double locks containing places for chemicals and various accessories. The roentgen ray tubes and valve tubes are carried in specially designed boxes which can be placed on each side of the body. There is a demountable aluminum top table which folds up and occupies very little space. There is also carried the regular French military demountable table for fluoroscopic localization. There is abundant room within the body for one of the portable Ledoux-Lebard outfits consisting of a coil and mercury interrupter. There is also room for the tube carrier which goes under the operating table." (The table, tube carrier, and other accessories are shown in Fig. 6.)

When the United States entered the war the only type of portable roentgen ray apparatus in use by our army was one consisting of a very heavy gas engine operating a dynamo, the latter having a disc on its shaft to revolve in contact with brushes connected to the terminals of a high tension transformer. This apparatus was cumbersome and its output small.

It was necessary to decide whether the portable apparatus to be adopted by our medical department should be complete in itself with a separate gas-electric generating set, or whether we should depend upon the motor of the automobile for power. A number of reasons, based upon reports of American military observers, influenced the Surgeon General's Office to adopt a portable outfit having a separate gas-electric set. It was observed that automobile engines, not being constructed for this kind of service, got out of order very frequently, not only interfering with

FIG. 3. LATEST TYPE OF ENGLISH ROENTGEN RAY CAMION.

the operation of the dynamo for roentgen ray work, but resulting in frequent delays on the road due to motor trouble. After a heavily loaded truck has been driven a considerable distance, possibly over difficult roads, time must be given to overhauling the motor if it is to be kept in good working order, and of course this cannot be done if the motor is run continuously to operate roentgen ray apparatus after arriving at its destination. Another consideration is that accident to the motor on the road results in disabling the entire roentgen ray outfit, since it depends upon the automobile motor for its power.

The portable apparatus adopted by the medical department is that developed by Dr. W. D. Coolidge. It derives its great advantage over other portable apparatus from the use of a special radiator type of Coolidge tube which rectifies its own current. It permits us not only to use a high tension transformer instead of the coil with the troublesome interrupter, but also eliminates the synchronous motor and revolving devices for rectifying the current. Fig. 7 shows the apparatus without the gas engine, set up in connection with the portable table. Actual practical work under the difficult conditions of war has demonstrated that this is an entirely satisfactory portable outfit. It is true that the maximum output is only 10 milliamperes, but the very fine focus of the new radiator tube makes it possible to do perfectly satisfactory roentgenography of all parts of the body. I will give no detailed description of the apparatus here since it has already been described by Dr. Coolidge, and description of its construction and operation will be found in the U. S. Army X-Ray Manual.

After this apparatus was decided upon it was necessary to determine the type of vehicle in which it was to be transported,

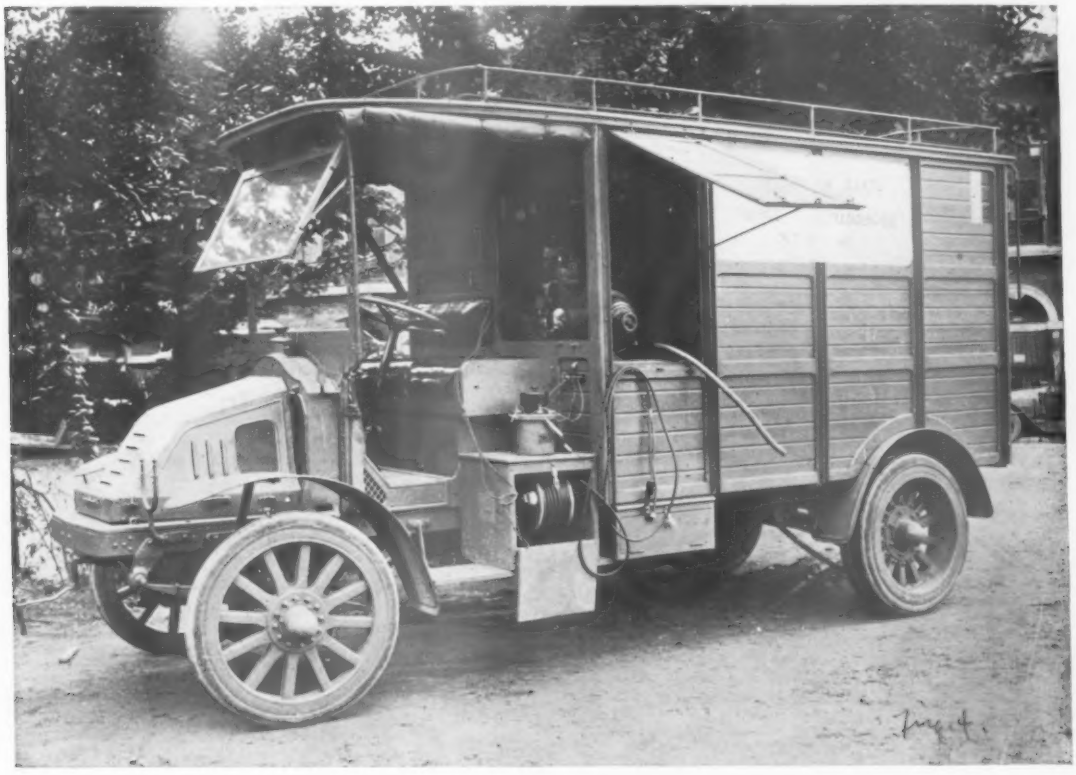


Fig. 4. Earlier Type of French Roentgen Ray Camion.

the method of packing, and what accessories were to be furnished. It seemed very desirable to choose, if possible, some standard medical department vehicle instead of devising an entirely new outfit. An automobile which was already standardized could be much more readily secured in sufficient number, and the problem of spare parts and repairs would be greatly simplified. The standard U. S. Army automobile ambulance seemed suited to our purpose and it was found after some experimentation that it could easily be modified so as to carry safely and conveniently the entire roentgen ray outfit with all necessary accessories. This modification was carried out under the direction of Lt. Col. George C. Johnston, M. C., U. S. A.

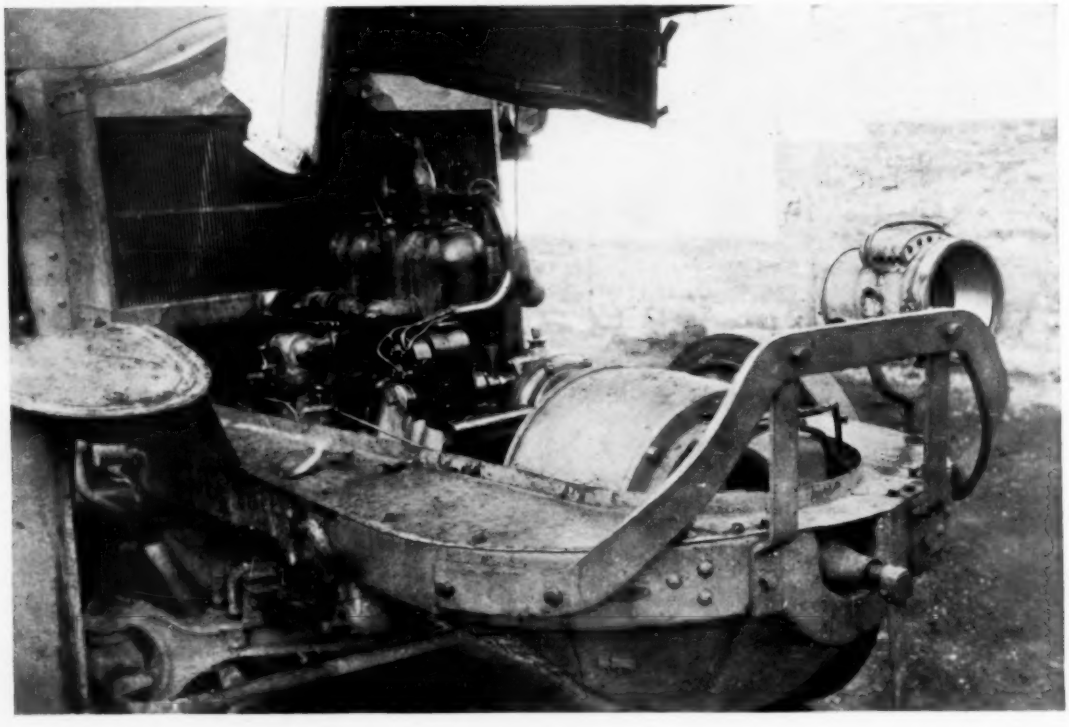


FIG. 5. LATEST TYPE OF FRENCH ROENTGEN RAY CAMION, SHOWING MOUNTING OF DYNAMO IN FRONT OF ENGINE.

The standard army ambulance is mounted on a three-quarter ton chassis. It was modified in the following manner to transport the portable roentgen ray apparatus:

The seating arrangements of the standard body are removed, and also the devices for supporting the army litters. Across the front of the body, immediately behind the driver's seat, tying the sides together, is a platform of 2″ plank upon which is securely bolted the Delco gas-electric set with its switchboard, etc., complete. (Fig. 8.) This plank mounting acts as a spring support for the engine and reduces the vibration to a minimum. Packed in the interior of the body are the parts of the portable roentgen ray table, the roentgen ray tube box with its shutters, a portable dark room, an army bedside unit to serve as a spare roentgen ray apparatus, a carrying case for the radiator tubes, the box containing the high tension and Coolidge tube transformers and all the other electrical parts of the portable apparatus, and a box of the standard localizing apparatus. The chemicals, trays, films and other dark room accessories are contained in the portable dark room mentioned above. There is also provided a light-tight canopy with a

gaspipe frame for its support which can be erected within any building at hand, or, if necessary, in the open, to serve as a fluoroscopic room. All of this apparatus rides safely in the modified ambulance and does not overload it. On the sides of the body are carried three wood bakelite tops for the portable table. The side curtains of the ambulance are longer than usual and are provided with end flies. The supports for the table tops are hinged and may be dropped down to the horizontal. The side curtain having been drawn over the table tops and the end flaps fastened beneath them, there is provided an excellent pair of tent covered cots upon which

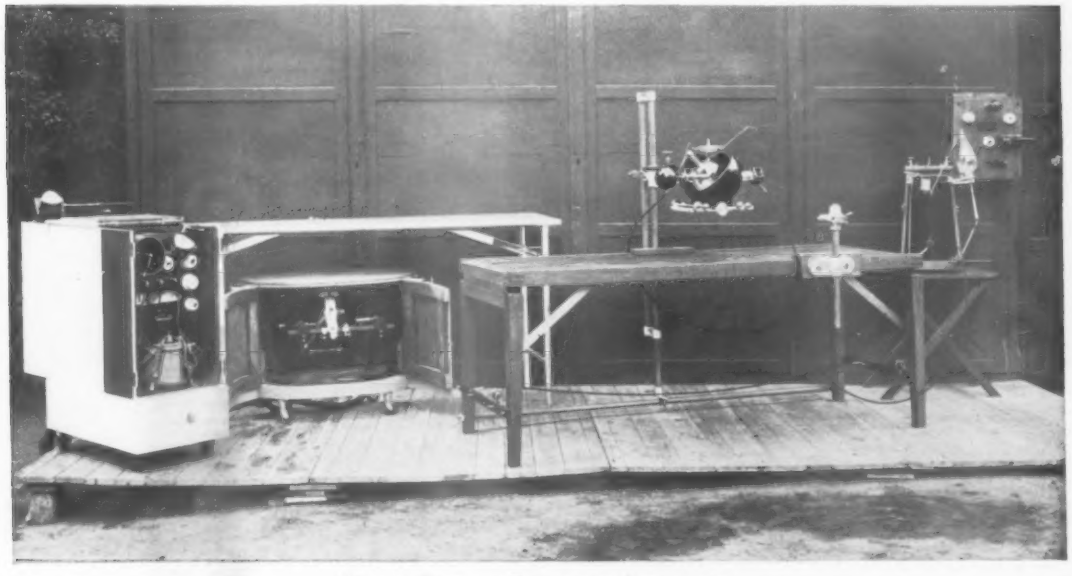


FIG. 6. FRENCH PORTABLE APPARATUS.

FIG. 7. AMERICAN PORTABLE APPARATUS WITHOUT ENGINE.

the chauffeur and technician may sleep. (Figs. 9, 10.) The officer in charge can sleep on the third table top placed on top of the apparatus inside the ambulance.

This outfit was adopted by the Surgeon General's Office after a 2,000 mile road test. It was found practicable to do the entire work of one of our large cantonment hospitals with it when the hospital's apparatus was out of order. The roentgen ray apparatus itself has been thoroughly tested both in this country and in France.

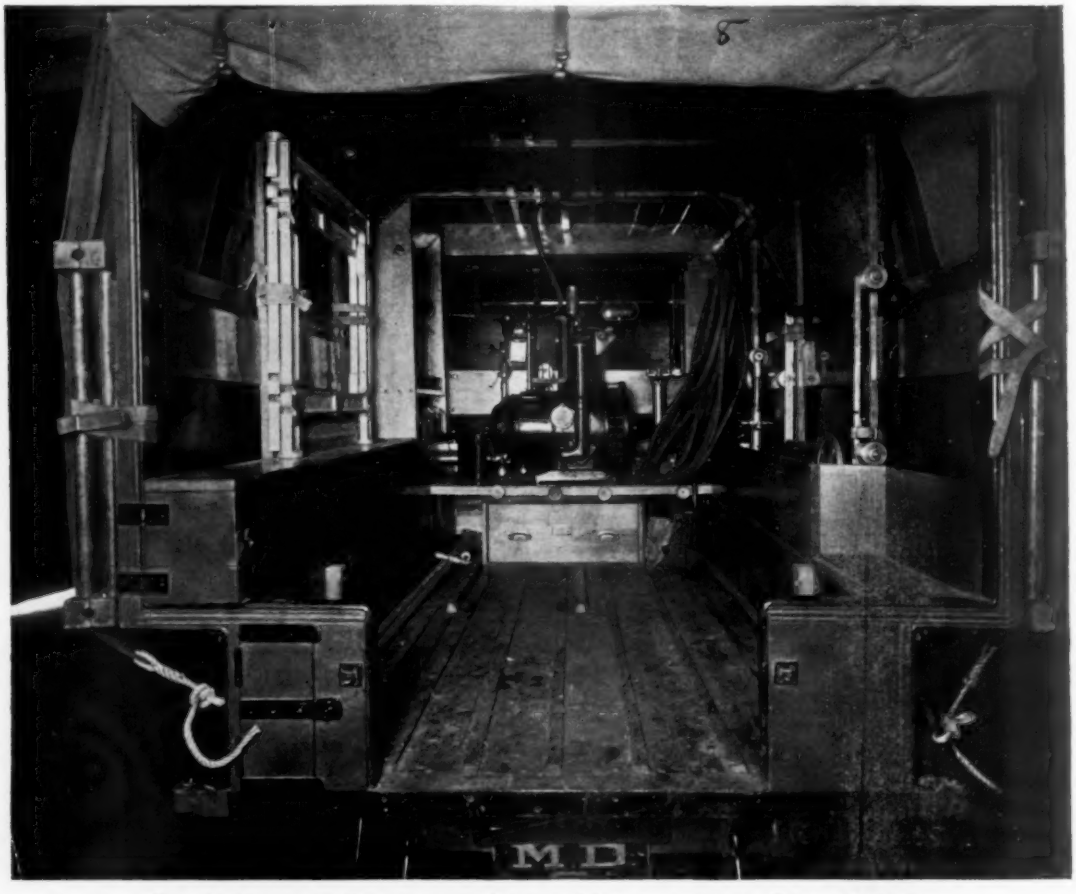


FIG. 8. AMERICAN CAMION WITH ENGINE MOUNTED BEHIND DRIVER'S SEAT.

Unfortunately, our modified ambulances did not reach France in time to be placed in operation until after the beginning of the armistice. They have been very thoroughly tested, however, in the Army of Occupation by Lt. Col. E. A. Merritt, M. C., U. S. A., who had charge of roentgen ray work with that army. Lt. Col. Merritt's previous experience in charge of roentgen ray work with the First Army during the time of its active operations renders his judgment on this matter of particular value. His report states that the modified ambulance is entirely satisfactory as a means of transporting the roentgen ray apparatus, with the exception of a few minor changes. The rear tires must be heavier than those on the standard ambulance, and the rear springs must have one extra leaf. All these camions sent to the Army of Occupation were provided with an extra Delco engine to be used for lighting purposes, and with wiring and bulbs for thirty-five lights. It was found by experience that field and mobile hospitals practically always depend upon the roentgen

ray department to furnish lights. Even evacuation hospitals depend upon the engineer department to furnish the necessary to provide current for lights until the engineering department is able to install a plant. In the French and English camions

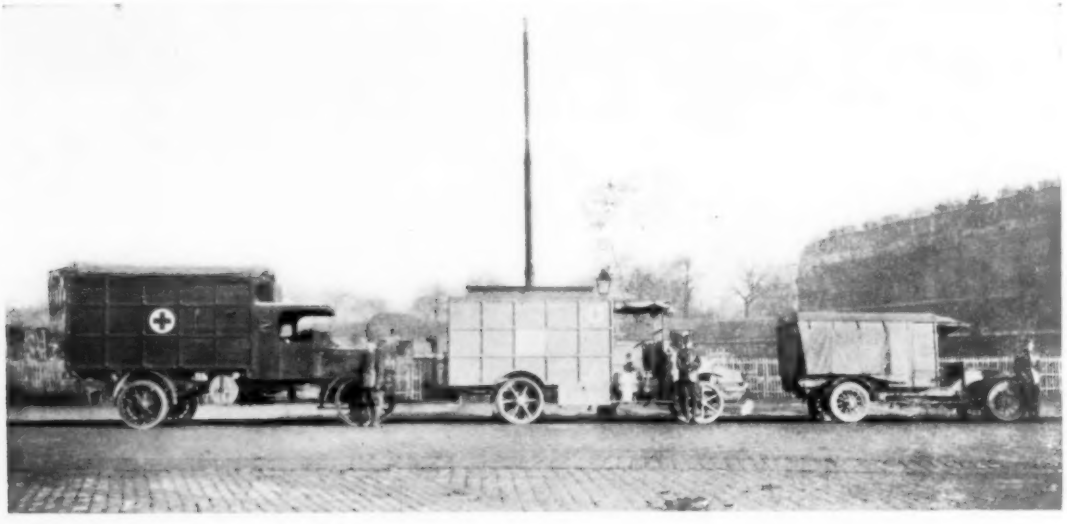
Fig. 9. American Camion with Table Top Arranged for Sleeping.

Fig. 10. American Camion Ready for the Road.

lighting outfits, and in numerous cases the roentgen ray generating outfit has been used for the first twenty-four or forty-eight hours the lights are supplied with current from the same dynamo that furnishes power for the roentgen ray machine. Experience

showed that this was not satisfactory. There was often great variation in the current to the roentgen ray tube depending upon the number of lights in use, and at times there was lack of penetration due to overloading the line. These objections are eliminated by the use of an extra engine for lighting purposes alone.

Because of the late arrival of our own camions in France, it was necessary for Lt. Col. Case, Senior Consultant in Roentgenology with the American Expeditionary Forces, to equip our mobile hospitals with the French camions described above. Most of these were equipped with the standard French apparatus, but a few of them were furnished with the American portable outfits. Excellent work on many thousands of cases was done with the French apparatus. The mercury interrupter, however, was a source of great annoyance, and the use of gas and valve tubes is of course much less satisfactory than the Coolidge tube.



FIGS. 11 AND 12. ENGLISH, FRENCH AND AMERICAN CAMIONS, IN ORDER LEFT TO RIGHT.

Comparison of the English, French and American camions may be made by reference to Figs. 11 and 12. It will be seen that the American type is much smaller than either of the others. Fully equipped, it weighs about half as much as the French and about a third as much as the English.

The advantage of the English and French camions over the American is that the two former have the body of the car arranged for a dark room, while the latter has not. Experience in this war has shown that the greater part of the roentgen ray work in all hospitals in the forward areas, including evacuation hospitals, is fluoroscopic. An elaborate dark room is therefor unnecessary. The few plates that will be made can be conveniently developed in the small portable dark room furnished with the American apparatus.

The advantages of the American type of apparatus which are now apparent are as follows:

1. The automobile engine is not used to generate power for roentgen rays or lights, and can therefore be overhauled and placed in order between trips.

2. It is much lighter than the English and French types, and has a powerful engine rendering it very mobile. It is doubtful if the heavy types of camions could be operated to advantage over roads less good than those in France.

3. It is essentially the United States Army Ambulance, for which extra parts are carried in stock by the Army.

4. The apparatus is demountable, and can be placed in another camion or even in a truck and taken to its destination, if the original camion gets out of order.

5. The roentgen ray apparatus carried in this camion is not of special type but is the standard Army Portable Outfit.

6. Experiment has shown that the roentgen ray efficiency of the American portable apparatus is approximately eight times that of apparatus depending upon a coil and interrupter and gas and valve tubes.

It is believed that the American portable apparatus carried in the modified ambulance described above, with a few minor modifications tending to simplify it, is the most satisfactory mobile roentgen ray outfit yet devised.

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SIR JAMES MACKENZIE DAVIDSON, M.B., C. M.

THE JOURNAL regrets to announce the death on April 2d, at the age of sixty-two, from heart failure, of one of the world's foremost roentgenologists, Sir James Mackenzie Davidson. His death, which took from the field of roentgen ray diagnostics and therapy one of the pioneers in this department of medical science, is a world's loss which comes home to THE AMERICAN JOURNAL OF ROENTGENOLOGY; for we are deprived of the help of one who has for several years acted as the British representative on our staff of collaborators, and who has been one of the few honorary members of THE AMERICAN ROENTGEN RAY SOCIETY.

Before the advent of the roentgen ray, Mackenzie Davidson was an ophthalmic surgeon. Naturally when the roentgen ray was added to the medical armamentarium, Sir James gave his first thoughts to its adaptation to the diseases and particularly to surgery of the eye. In 1897, he and Hadley published articles on the triangulation method of foreign body localization, visualizing in space the position of the foreign body by means of crossed threads. The same year, Mackenzie Davidson successfully produced stereofluoroscopy for the first time. This achievement laid the foundation for the train of experimental work, closely followed up by Caldwell of New York, which culminated in the production by Caldwell of a practical stereofluoroscope, described in these columns a few months ago. As early as July, 1897, Davidson published a roentgenogram of a bladder stone, and foresaw the usefulness of the roentgen ray in the diagnosis of renal calculi.

James Mackenzie Davidson's father was an early settler in Brazil, and the son was born there and received his early education in the Scottish school of Buenos Aires. He studied medicine in Edinburgh, London, and Aberdeen, graduating at the latter university in 1882 with the degrees of M. B., C. M. His early practice took him at once into the specialty of eye surgery, which claimed the major interest in his life for the next two decades. In 1886 he became ophthalmic surgeon to the Aberdeen Royal Infirmary and to the Royal Hospital for Sick Children, which positions he held until 1895. All this time he was lecturer in ophthalmology in the

University of Aberdeen, where his inborn qualities as an instructor attracted large numbers to his classes. Not a few of his students have since distinguished themselves in ophthalmic work.

His friends bear witness to his unfailing cordiality, his keen personal interest in all who took their problems to him, and his kindness and courtesy to his patients.

Mackenzie Davidson's natural bent toward physics gave him early a familiarity with the experimental and practical phases of electricity and light (and, by the way, of this store of knowledge he gave freely toward the education of the public by popular lectures, lavishly illustrated by costly experiments). Naturally, Davidson was prompt in recognizing the importance of Roentgen's discovery and its import to the future of medicine and surgery. He at once set about the production of the roentgen rays, and was probably the first in Scotland to produce and utilize the new rays. He continued his investigations in Aberdeen until in 1897 he removed to London, where he continued his work until his death.

Sir James Mackenzie Davidson

His interest in physics and a natural genius for invention led him all his life to continue his efforts to improve old and devise new roentgen ray apparatus. His invention of the stereofluoroscope has already been referred to, as well as his "cross-thread localizer." Davidson was so thoroughly impressed with the value of the stereoscopic method that he not only taught it but consistently practiced it in practically all his examinations.

In 1890, he described a new form of rotary mercury interrupter, which came into general use as the Mackenzie Davidson "break." One of his latest inventions was a roentgen ray couch (described last year in the pages of this JOURNAL) especially designed for war work and permitting very rapid localization of foreign bodies.

A further accomplishment of our distinguished friend was the development of a telephone attachment for use in localizing foreign bodies. This was a telephonic attachment to forceps which could be opened to include the foreign body as well as to act as a probe. This and his cross-thread localizer were tested out in the South African war, as well as during the European war just closing.

In addition to his interest in the roentgen rays, Davidson was one of the earliest workers with radium, and he was one of the first to suggest the value of radium-therapy in certain forms of roentgen ray dermatitis.

In 1916, Davidson became honorary consulting roentgenologist to the military hospitals of the London districts, though he regretted keenly his inability to take a commission and go out to France.

In 1912–13, he was president of the Roentgen Society of London, and of the Radiology Section of the International Congress of Medicine in London in 1913. At the time of his death, he was consulting surgeon of the *X*-ray Department of the Royal London Ophthalmic Hospital, Moorfields, and of Charing Cross Hospital.

Dr. Thurstan Holland, a close friend of the deceased, writes: "My feeling about the value of his work and the originality of many of his inventions is that the work was done at a time when so little was known about *x*-ray apparatus, when even the means of energizing an *x*-ray tube was primitive, and when the difficulties were so very great. He showed the way to many of us. He was a man who always welcomed anyone interested in *x*-ray work, and he was always ready and willing to show his methods and demonstrate his intruments to his fellow workers."

Those of us Americans who have enjoyed the privilege of friendship with this talented pioneer heartily endorse the foregoing tribute, and take this opportunity of offering to Lady Davidson and other members of the family the sympathy of American roentgen ray workers.

JAMES T. CASE.

X-RAY TRAINING OF MANIPULATORS BY U. S. ARMY

Young men entering the army are offered opportunity to become X-ray manipulators, as will be seen by the following:

The U. S. Army is offering to men enlisting for a three-year term many educational advantages. Young men possessing preliminary education may enlist in the Medical Corps with a view to training as X-ray manipulators. They will be given a three months' course at the Army Medical School, Washington, D. C. The course of instruction will cover Electro-physics, construction and operation of all types of X-ray apparatus, including the U. S. Army X-ray Ambulance, the Bedside X-ray unit, the portable field type of apparatus, dark room work, photography, electrical wiring, installation, care and repair of X-ray and electrical apparatus, gas engine construction, care and repair, etc.

Application for this enlisting should be made to the Surgeon-General, U. S. Army, Washington, D. C., attention of the Chief, Section of Roentgenology.

David R. Bowen M.D.